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Staging, Storage, Sizing, and Treatment Facility (SSSTF)

Debris Treatment Process Selection and Design

Prepared for:
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5. Summary:

The purpose of this document is to analyze possible debris treatment options, to select a debris treatment process, and to provide the design and process for debris treatment for the Staging, Storage, Sizing, and Treatment Facility (SSSTF) design. A soil treatment process, cement-based stabilization, has been selected and is currently being designed to comply with the waste-specific treatment standards in 40 CFR 268.40 and/or soil specific treatment standards in 40 CFR 268.49. Hazardous debris, subject to the Treatment Standards for Debris (40 CFR 268.45), will also be processed in the SSSTF and must be processed accordingly. Although soil and debris processing requirements are similar, they are subject to different standards.

Several debris treatment technologies were identified in accordance with the Alternative Treatment Standards for Debris in Table 1 of 40 CFR 268.45. Technologies considered were from three general categories: extraction, destruction, and immobilization. The technologies were prescreened and further analyzed against evaluation criteria, including quality control, operations, cost, implementability, inherent safety, and flexibility.

Based on the analysis performed in this study, cement-based microencapsulation was selected as the primary debris treatment process to be utilized in the SSSTF. This treatment process will be used to treat all known debris delivered to the SSSTF.

6. Review (R) and Approval (A) and Acceptance (Ac) Signatures:
(See instructions for definitions of terms and significance of signatures.)

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Performer	R	C. J. Hurst	[signature]	3/11/02
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ACRONYMS

ALARA	as low as reasonably achievable
AOC	area of contamination
BDAT	best demonstrated available technology
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
D&D&D	deactivation, decontamination, and decommissioning
DOE	Department of Energy
DOE-ID	Department of Energy Idaho Operations Office
EDF	Engineering Design File
EPA	Environmental Protection Agency
HEPA	high-efficiency particulate air (filter)
HW	hazardous waste
HWMA	Hazardous Waste Management Act
ICDF	INEEL CERCLA Disposal Facility
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
LDR	land disposal restriction
MLLW	mixed low-level waste
OU	operable unit
PCB	polychlorinated biphenyl
PPE	personal protective equipment
RCRA	Resource Conservation and Recovery Act
RD/RA	remedial design/remedial action
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision

SSSTF	Staging, Storage, Sizing, and Treatment Facility
TFR	technical and functional requirements
TSCA	Toxic Substances Control Act
WAC	Waste Acceptance Criteria
WAG	waste area group

Staging, Storage, Sizing, and Treatment Facility (SSSTF) Debris Treatment Process Selection and Design

1. INTRODUCTION

The U.S. Department of Energy Idaho Operations Office (DOE-ID) authorized a remedial design/remedial action (RD/RA) for the Idaho Nuclear Technology and Engineering Center (INTEC) in accordance with the Waste Area Group (WAG) 3, Operable Unit (OU) 3-13 Record of Decision (ROD) (DOE-ID 1999).

The ROD requires Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remediation wastes generated within the Idaho National Engineering and Environmental Laboratory (INEEL) boundaries to be removed and disposed of on-Site in the INEEL CERCLA Disposal Facility (ICDF). The ICDF, which will be located south of INTEC and adjacent to the existing percolation ponds, will be an on-Site, engineered facility, meeting Department of Energy (DOE) Order 435.1, the substantive requirements of Resource Conservation and Recovery Act (RCRA) Subtitle C, Idaho Hazardous Waste Management Act (HWMA), and Toxic Substances Control Act (TSCA) for polychlorinated biphenyl (PCB) landfill design and construction substantive requirements. The ICDF Complex will include the necessary subsystems and support facilities to provide a complete waste disposal system.

The major components of the ICDF are the disposal cells, the evaporation pond system, and the Staging, Storage, Sizing, and Treatment Facility (SSSTF). The disposal cells, including a buffer zone, will cover approximately 40 acres, with a disposal capacity of about 510,000 yd^3. Currently, approximately 562 yd^3 of hazardous debris have been identified that may require treatment as described in this Engineering Design File (EDF).

The SSSTF is designed to provide centralized receiving, inspection, and disposition necessary to stage, store, repackage and treat incoming waste from various INEEL CERCLA remediation sites prior to disposal in the ICDF, or shipment off-Site. All SSSTF activities shall take place within the WAG 3 area of contamination (AOC) to allow flexibility in managing the consolidation and remediation of wastes without triggering land disposal restrictions (LDRs) and other RCRA requirements, in accordance with the OU 3-13 ROD. Only low-level, mixed low-level, hazardous, and limited quantities of TSCA wastes will be treated and/or disposed of at the ICDF. All ICDF leachate, decontamination water, and water from CERCLA well purging, sampling, development, and other CERCLA activities will be disposed of in the ICDF evaporation pond system.

One of the functions of the SSSTF is to receive, stage, store, and treat "hazardous debris" as part of the CERCLA cleanup activities identified in the OU 3-13 ROD. Hazardous debris is defined as debris that contains a hazardous waste (HW) listed in the Code of Federal Regulations (CFR) (Subpart D of 40 CFR 261) or that exhibits a characteristic of HW, as identified in Subpart C of 40 CFR 261. Debris, by definition, is material greater than 60 mm (2.36 in.) in size (or is a mixture of waste that visually consists primarily [i.e., >50%] of debris by volume) and that does not have a specific treatment standard as provided by Subpart D of 40 CFR 268. The waste is not debris if a specific treatment standard exists in Subpart D of 40 CFR 268.

Because obtaining a representative sample of debris is a major obstacle, the Environmental Protection Agency (EPA) established alternative treatment standards. The alternative treatment standards are required technologies that fall into three generalized categories: extraction, destruction, and immobilization. Each, of these technologies, was evaluated in order to select a primary debris treatment process for the SSSTF as described in this EDF.

1.1 Purpose and Objective

The purpose of this document is to describe the evaluation and selection of a debris treatment process for the SSSTF. An evaluation of the different debris treatment processes as described in the alternative treatment standards (40 CFR 268.45) was conducted. A specific process was then selected through a value engineering session. The evaluation included a review of the current projected volumes of debris waste streams, sampling issues, direct disposal opportunities, sizing requirements, and preferred treatment techniques. This document also provides design information for the selected debris treatment process and the components necessary for treatment. A more detailed list of the procedures describing the treatment process will be provided in the SSSTF Operations and Maintenance Plan that will be submitted as part of the ICDF Complex Remedial Action Work Plan.

This EDF is organized as follows:

- Section 1 provides background information on the SSSTF and discusses the importance and role of a debris treatment process in the SSSTF.
- Section 2 discusses the design criteria and lists the assumptions used to select and design a debris treatment process.
- Section 3 defines the debris waste inventory, including information on volumes, media, etc.
- Section 4 identifies the treatment options that were considered for debris in the SSSTF, based on the "Alternative Treatment Standards for Hazardous Debris" (40 CFR 268 Subpart D).
- Section 5 describes the treatment technology selection process.
- Section 6 describes in detail the selected debris treatment option for the SSSTF.

1.2 Process Selection Methodology

The process used to select a debris treatment technology involved an initial prescreening of the alternative treatment technologies (see Section 4) into a list of feasible technologies, based upon defined criteria. The list of prescreened technologies was further defined, and a panel of engineers, regulatory personnel, scientists, and project managers then developed a set of evaluation criteria and weighting for those criteria. Each member of the value engineering panel individually rated each of the alternatives relative to the evaluation criteria. This process resulted in the selection of debris treatment technologies that best meet the designated requirement and evaluation criteria set forth in the evaluation. Specific details of the value engineering process are further described in Section 5.

2. DESIGN REQUIREMENTS AND KEY ASSUMPTIONS

The debris treatment process selected will be designed to treat a minimum of 562 yd^3 of hazardous debris from release sites CPP-92, CPP-98, CPP-99, and TSF-07 and deactivation, decontamination, and decommissioning (D&D&D) activities. Other CERCLA-generated hazardous debris may be added to the debris treatment inventory, provided the waste does not meet the ICDF landfill Waste Acceptance Criteria (WAC). The selected debris treatment process will be designed in accordance with general and performance requirements, as listed in the technical and functional requirements (TFRs) document (see TFR-17, WAG 3 Staging, Storage, Stabilization, and Treatment Facility). The debris treatment process will be a RCRA-approved technology, in accordance with Subpart D of 40 CFR 268.45, so that the treated debris waste may be disposed in the ICDF landfill. Table 2-1 lists assumptions, interpretations, and any issues associated with potential variations of the interpretations.

The scope of this evaluation is to select a primary debris treatment process for the ICDF Complex. It is feasible that a nonselected treatment may be used to treat some debris on a case by case basis. Discussion regarding use of other treatment technologies is included in this evaluation. Additionally, all of the treatment technologies were assumed to be stand-alone technologies. For the purposes of selecting a primary treatment process, it was assumed that there would be no pretreatment of the debris such as washing or size reduction. Furthermore, it was assumed that size reduction had occurred when the debris was placed in boxes and that no additional size reduction was necessary.

2.1 Debris Characteristic Assumptions

In addition to regulatory requirements, interpretations, and assumptions listed in Table 2-1, additional assumptions were made regarding the debris characteristics. These assumptions are as follows:

- The waste inventory is not considered ignitable, corrosive, or reactive.

- Newly generated waste is adequately characterized by the generator prior to shipment to the ICDF Complex and requires no pretreatment sampling. Debris waste currently in the SSA from sites CPP-92, -93, and -99 will be addressed in the RD/RA work plan for these sites and characterized as required prior to treatment, if necessary.

- Any secondary waste generated as a result of operating the treatment facility either meets the ICDF landfill and/or evaporation pond WAC or can be treated to meet the WAC using existing treatment processes in the SSSTF.

These additional assumptions were used for the evaluation and implementation of a debris treatment process in the SSSTF.

Table 2-1. Regulatory interpretations, assumptions, and issues.

Category	Interpretation	Assumptions	Issues
Debris definition	Hazardous waste that is greater than 60 mm (2.36 in.) in size (or is a mixture of waste that visually consists primarily [i.e., >50%] of debris by volume) and that does not have a specific treatment standard as provided by Subpart D of 40 CFR 268.	Debris will be segregated from nondebris by the generator prior to being shipped to the SSSTF, unless the mixture is comprised primarily of debris.	The SSSTF is not designed to segregate materials.
Debris treatment technologies	The Alternative Treatment Standards for Hazardous Debris are technology-based treatment standards that fall into three categories: extraction, destruction, and immobilization.	The basis for debris treatment technology evaluation and selection is limited specifically to the technologies identified in Table 1 of 40 CFR 268.45.	
Post-treatment sampling	If using the technology-based treatment standard (40 CFR 268.45), rather than concentration-based treatment standards, the treated wastes can be land-disposed without being tested.	Post-treatment sampling of debris is not required and will not be performed.	
Asbestos debris	Asbestos debris is amenable to debris treatment, in some cases, provided appropriate filtration and handling systems are in place.	The waste will not contain any free asbestos. Asbestos containing material must meet 40 CFR 761 regulations for packaging.	Handling of free asbestos requires a higher level of containment than what is currently proposed in the SSSTF/ICDF design.
PCB-contaminated debris	Contaminated debris is subject to TSCA regulations and must be treated to these requirements.	The waste will not contain any PCBs greater than 500 ppm or if the waste has a nonporous surface, the surface concentration will be less than 100 $\mu g/100\ cm^2$.	The ICDF landfill will not be designed to dispose of PCBs in excess of the PCB-contaminated material concentrations designated in 40 CFR 761.3; nor will the SSSTF provide for PCB treatment in excess of the concentrations for PCB-contaminated material in 40 CFR 761.3.
Inherently hazardous debris	Debris classified as "inherently hazardous"[a] must be immobilized following appropriate treatment for other contaminants subject to treatment.	"Inherently hazardous" debris[a] will be treated using the immobilization technologies (i.e., microencapsulation).	

a. Inherently hazardous debris is defined as types of debris that will fail the TCLP because of their inherent metal content (on page 8.19 of the LDR Compliance guide [Elsevier 1999]).

3. DEBRIS WASTE INVENTORY

A review of the candidate waste streams for debris treatment revealed a total of 562 yd^3 of debris that may require treatment. Boxed wastes in the Staging and Storage Annex (CPP-92, CPP-98, and CPP-99) were identified as the primary debris-containing waste streams, in addition to smaller quantities from TSF-07 and D&D&D waste. The currently identified debris waste streams entering the ICDF Complex are listed in Table 3-1. This table sorts the release sites into individual WAGs and provides a volume for each corresponding waste site. It is anticipated that as remediation activities are being performed, additional debris waste streams requiring treatment will be identified.

Because obtaining a representative sample of debris is a major problem, the EPA established alternative treatment standards for debris based on the use of required technologies. Since minimal characterization data exist for the CPP-92, CPP-98, and CPP-99 waste, it was slated for treatment using one of the technologies listed in the 40 CFR 268.45, Table 1, "Alternative Treatment Standards for Hazardous Debris."

Even though no analytical samples have been taken from the debris waste from release sites CPP-92, CPP-98, and CPP-99, these wastes have been slated for treatment because they were generated from projects having RCRA listed constituents and have triggered placement. The debris waste from these release sites carry F001, F002, F005, and U134 waste codes based on process knowledge. The CPP-92 debris waste was generated during various INTEC construction activities including the tank farm upgrade, CERCLA remediation projects, the CPP-603 cleanup, excavation for the fire exit from building CPP-604/605, and other miscellaneous excavations at INTEC where soil contamination was encountered. Although the debris boxes were never sampled, some characterization was conducted on the CPP-92 soil boxes. No organics were detected and the only inorganic constituents detected were arsenic, mercury, and selenium. Mercury was the only constituent detected at concentrations that may exceed characteristic levels.

The debris waste in site CPP-98 originated from the tank farm upgrade project, and the majority of the debris is wooden shoring that became contaminated. The 35 boxes of debris in CPP-99 also originated from the tank farm upgrade and the CPP-604 tunnel egress project. No characterization of this waste has been performed.

Based on process knowledge, it has been assumed that although the CPP-92, CPP-98, and CPP-99 boxes carry F001, F002, and F005 waste codes for organic constituents, and the U134 waste code for hydrogen fluoride, the constituents are below treatment thresholds. Existing information for these boxes of debris waste is summarized in Table 3-2.

The TSF-07 waste (1 yd^3 of personal protective equipment [PPE]) has also been slated for treatment prior to disposal, since no characterization data are available.

In addition, the *OU 3-13 Closure Evaluation Criteria Checklist* (DOE-ID 2000a) provides a mechanism for the treatment and ICDF disposal of D&D&D wastes. The D&D&D wastes are further discussed in the *CERCLA Waste Inventory Database Report for the OU 3-13 Waste Disposal Complex* (DOE-ID 2000b) in which 72 yd^3 of mixed low-level waste (MLLW) and HW fractions are identified for debris treatment. (Currently, D&D&D wastes are not considered CERCLA-generated and would have to be designated as CERCLA-generated prior to treatment and/or disposal at the ICDF Complex.)

Table 3-1. List of debris generation sites.

WAG	Release Site	Volume (yd^3)	Designated Waste Codes
3	CPP-92	173	F001, F002, F005, U134
	CPP-98	220	F001, F002, F005, U134
	CPP-99	96	F001, F002, F005, U134
1	TSF-07	1	F001
	D&D&D	72	This is a potential waste stream that has not been characterized.

Table 3-2. Boxed waste content summary.

	Release Site				
Debris	CPP-92	CPP-98	CPP-99	TSF-07	Total Boxes
Wood (including nails, bolts, etc.)	—	98	1	—	99
Metal (piping, rebar, angle iron, conduit, I-beams, air compressors, etc.)	1	2	5	—	8
Concrete (including rebar, conduit, asphalt, etc.)	40	—	29	—	69
Noncompactible (soil, asphalt, concrete)	18	—	5	—	23
PPE	—	—	—	1	1
Miscellaneous	—	1	4	—	5
Total	59	101	44	1	205

4. ALTERNATIVE TREATMENT TECHNOLOGIES

4.1 Alternative Definitions

Debris treatment has created LDR issues for the EPA since the inception of the LDR program. EPA recognized that debris was a unique waste stream and developed alternative standards as BDAT[a] for those materials over 60 mm (2.36 in.) that are intended for disposal and are manufactured objects, plant or animal matter, or natural geologic material. Because obtaining a representative sample of debris is a major problem, the agency developed alternative standards based on the use of required technologies. This approach has been used for other hazardous wastes when analytical difficulties rule out establishment of concentration-based treatment standards. Therefore, this EDF has been limited to the use of the technologies outlined in the regulations (40 CFR 268.45, Table 1).

This section identifies and describes all options that were considered for debris treatment in the SSSTF. The options have been taken directly out of 40 CFR 268.45.

4.1.1 Extraction Treatments

Three general categories of extraction were considered: physical extraction, chemical extraction, and thermal extraction. Within each of these categories, specific technology types were considered and are briefly described below.

Physical extraction - Five physical extraction technologies were considered in this evaluation, including (1) abrasive blasting; (2) scarification, grinding, and planing; (3) spalling; (4) vibratory finishing; and, (5) high-pressure steam and water sprays. The performance standards for physical extraction technologies are based on removal of the contaminated surface layer of hazardous debris to a "clean debris surface".

Chemical extraction - Three specific technologies of chemical extraction were considered in this evaluation: (1) water washing and spraying, (2) liquid-phase solvent extraction, and (3) vapor-phase solvent extraction. The performance standards for chemical extraction technologies are based on dissolution of contaminants into the cleaning solution.

Thermal extraction - EPA identified two thermal extraction processes that are suitable for treating hazardous debris: high temperature metals recovery and thermal desorption.

4.1.2 Destruction Treatments

Three destruction technologies were considered in this evaluation: (1) biological destruction, (2) chemical destruction, and (3) thermal destruction.

Biological destruction - This is also known as biodegradation. It was not broken down into subcategories.

Chemical destruction - Two forms of chemical destruction were considered. The first is chemical oxidation, in which the organic constituent is oxidized to destroy its chemical character. The second is chemical reduction, in which the organic is chemically reduced to destroy its chemical character.

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a. BDAT – Best demonstrated available technology – The treatment standards require either that wastes be treated (1) to meet designated concentration-based limits for contained hazardous constituents or (2) using specific technologies.

Thermal destruction – This technology uses heat to destroy the contaminants. It was not broken down into subcategories.

4.1.3 Immobilization Treatments

Four immobilization technologies were identified in the alternative treatment standards: (1) macroencapsulation with polymeric organics, (2) macroencapsulation with inorganic materials, (3) microencapsulation with inorganic materials, and (4) sealing.

Macroencapsulation with polymeric organics – This technology requires application of surface-coating materials manufactured with polymeric organics to jacket the debris and substantially reduce the surface exposure to potential leaching media.

Macroencapsulation with inorganic materials – Instead of using polymeric organics to jacket the debris material, the material is encased in a jacket of inorganic materials (e.g., Portland cement concrete) to substantially reduce the surface exposure to potential leaching media.

Microencapsulation with inorganic materials – This treatment is stabilization of the debris with Portland cement and/or lime/pozzolans to reduce the leachability of the hazardous contaminants on the debris.

Sealing – This treatment is application of an organic sealant, such as epoxy, silicone, or urethane compounds, that adheres tightly to the debris surface to avoid exposure of the surface to potential leaching media.

4.2 Technologies Prescreening

Four criteria were determined to best prescreen the different treatment technologies described above. The criteria are based on the three screening parameters used during the remedial investigation/feasibility study (RI/FS) process in the EPA Guidance for Conducting Remedial Characterization and Feasibility Studies Under CERCLA (EPA 1988) (e.g., effectiveness, implementability, and cost). Effectiveness for this analysis is based on technical feasibility, which is also a widely used screening criterion. Technical maturity and safety, environment, and health are criteria easily used for qualitative screening and are used to replace the cost criterion, as cost is not known for all of these technologies. Each of the criteria has equal importance (i.e., they are judged to either pass or fail). The four criteria are

- **Technical feasibility:** Technical feasibility is the effectiveness (i.e., "Will it work?") of the technology applied to the debris and the hazardous constituents requiring treatment.

- **Technical maturity:** Technical maturity is the level of technology development and availability. Fully developed processes that have been demonstrated will be retained.

- **Implementability:** This criterion is the perceived implementation of the technology including factors such as regulatory issues, ease of construction, operability, and others.

- **Safety, environment, and health:** This criterion is the perceived level of safeness of the technology to the environment and human health (i.e., environmentally friendly chemicals, safe operation and equipment, and minimization of secondary streams).

Table 4-1 provides the prescreening results based on the above criteria. The first column groups the technologies into one of the following categories: physical extraction, chemical extraction, thermal extraction, biological destruction, chemical destruction, thermal destruction, or immobilization. The second column shows specific technologies under each category. The third column shows whether the specific technology is retained for more detailed analysis or rejected based on the prescreening criteria. The fourth column provides the basis for applicability, and column five provides comments and a basis for the prescreening.

Those technologies in Table 4-1 that were retained for more detailed analysis or that could possibly be used in conjunction with other processes are listed below:

- Physical extraction
  - Abrasive blasting
- Chemical extraction
  - Water washing and spraying
- Immobilization
  - Macroencapsulation with polymeric organics
  - Macroencapsulation with inorganic materials
  - Microencapsulation with Portland cement and/or lime pozzolans
  - Sealing.

The technology description, performance standard, and contaminant restrictions for each of the retained debris treatment technologies per 40 CFR 268.45, Table 1, are shown in Table 4-2. Also included in Table 4-2 is a description of each of the prescreened treatment processes.

Table 4-1. Prescreening of alternative treatments for hazardous debris.

Technology Group	Specific Technology	Screening Status	Basis For Applicability	Comments
Physical extraction	Abrasive blasting	Retained	*Glass, metal, plastic, rubber*: Treat to a clean debris surface. *Brick, cloth, concrete, paper, pavement, rock, wood*: Remove at least 0.6 cm of the surface layer and treat to a clean debris surface.	This technology was retained because it appears suitable for most debris in inventory. It generates secondary waste, which is probably treatable with SSSTF stabilization process. Although there are safety concerns, the work could be conducted in an enclosure to reduce potential exposure pathways.
	Scarification, grinding, and planing	Rejected	*Glass, metal, plastic, rubber*: Treat to a clean debris surface. *Brick, cloth, concrete, paper, pavement, rock, wood*: Remove at least 0.6 cm of the surface layer and treat to a clean debris surface.	This was rejected because of safety concerns. It was seen as not appropriate for radionuclide-contaminated debris because of worker exposure. Not consistent with as-low-as-reasonably-achievable (ALARA) principles.
	Spalling	Rejected	*Glass, metal, plastic, rubber*: Treat to a clean debris surface. *Brick, cloth, concrete, paper, pavement, rock, wood*: Remove at least 0.6 cm of the surface layer and treat to a clean debris surface.	This was rejected based on technical feasibility. It is not suitable for most debris identified in inventory.
	Vibratory finishing	Rejected	*Glass, metal, plastic, rubber*: Treat to a clean debris surface. *Brick, cloth, concrete, paper, pavement, rock, wood*: Remove at least 0.6 cm of the surface layer and treat to a clean debris surface.	This was rejected because of safety concerns. It was seen as not appropriate for radionuclide-contaminated debris because of worker exposure. It is not consistent with ALARA principles.
	High-pressure steam and water sprays	Rejected	*Glass, metal, plastic, rubber*: Treat to a clean debris surface. *Brick, cloth, concrete, paper, pavement, rock, wood*: Remove at least 0.6 cm of the surface layer and treat to a clean debris surface.	This was rejected because of safety concerns and because of technical feasibility due to limitations as to what debris could be treated. It is probably only applicable to glass, metal, plastic, and rubber because surface layer removal would be difficult to control.
Chemical extraction	Water washing and spraying	Retained	*All debris*: Treat to a clean debris surface. Debris must be no more than 1/2 in. in one dimension. Contaminant must be soluble to at least 5% by weight in water solution.	Although limited to only some types of debris, this technology was retained since it could be readily performed in the planned decontamination facility. Most metals of concern in inventory are not water-soluble.

Table 4-1. (continued).

Technology Group	Specific Technology	Screening Status	Basis For Applicability	Comments
	Liquid-phase solvent extraction	Rejected	*All debris*: Treat to a clean debris surface. Debris must be no more than 1/2 in. in one dimension. Contaminant must be soluble to at least 5% by weight in solvent solution.	Most metals of concern in inventory are not soluble in most solvents. It generates a secondary waste stream not compatible with SSSTF stabilization processes.
	Vapor-phase solvent extraction	Rejected	*All debris*: Treat to a clean debris surface. Debris must be no more than 1/2 in. in one dimension. Contaminant must be soluble to at least 5% by weight in solvent solution.	Most metals of concern in inventory are not soluble in most solvents. It generates a secondary waste stream not compatible with SSSTF stabilization processes.
Thermal extraction	High-temperature metals recovery	Rejected	This requires smelting, melting, or refining furnace.	Furnace availability at INEEL is not plausible.
	Thermal desorption	Rejected	Heating in an enclosed chamber is required to vaporize hazardous contaminants.	This is not applicable to metals other than mercury.
Biological destruction	Biological destruction	Rejected	This is destruction of organic contaminants using biodegradation.	This is not applicable to metal treatment. It generates secondary waste, which could not be treated in SSSTF.
Chemical destruction	Chemical oxidation	Rejected	This is oxidation by reaction with a chemical oxidizing agent. Debris must be no more than 1/2 in. in one dimension.	This is not applicable to metal treatment.
	Chemical reduction	Rejected	This is reduction by reaction with a chemical reducing agent. Debris must be no more than 1/2 in. in one dimension.	This is not applicable to metal treatment.
Thermal destruction	Thermal destruction	Rejected	This is treatment of debris in an incinerator or industrial furnace. This is not applicable for metals (other than mercury) or for brick, concrete, glass, metal, pavement, and rock.	An incinerator is not considered a viable option at the INEEL.

Table 4-1. (continued).

Technology Group	Specific Technology	Screening Status	Basis For Applicability	Comments
Immobilization	Macroencapsulation with polymeric organics	Retained	This is application of polymeric encapsulation material to completely encapsulate debris. Because this treatment does not destroy hazardous constituents, the treated debris must be disposed in a Subtitle C landfill.	
	Macroencapsulation with inert inorganic materials	Retained	This is application of inert encapsulation material to completely encapsulate debris. Because this treatment does not destroy hazardous constituents, the treated debris must be disposed in a Subtitle C landfill.	
	Microencapsulation with Portland cement and/or lime pozzolans	Retained	This is intimate mixing of debris and immobilization agent to reduce leachability of hazardous contaminants. Because this treatment does not destroy hazardous constituents, the treated debris must be disposed in a Subtitle C landfill.	
	Sealing	Retained	This is application of a sealing agent to avoid exposure of debris surface to potential leaching media. Because this treatment does not destroy hazardous constituents, the treated debris must be disposed in a Subtitle C landfill.	

Table 4-2. Alternative treatment standards for hazardous debris (adapted from 40 CFR 268.45, Table 1) for retained technologies.

Technology Description	Performance and/or Design and Operating Standard	Contaminant Restrictions	Treatment Process
Abrasive blasting: Removal of contaminated debris surface layers using water and/or air pressure to propel a solid media (e.g., steel shot, aluminum oxide grit, plastic beads).	Glass, metal plastic, rubber: Treatment to a clean debris surface.[a]	All debris: none.	The process would utilize recyclable material that would be "blasted" at the debris through a remotely operated nozzle.
	Brick, cloth, concrete, paper, pavement, rock, wood: Removal of at least 0.6 cm of the surface layer; treatment to a clean debris surface.[a]		For safety reasons, this technology would be used in an enclosure with a high-efficiency particulate air (HEPA) filtration system to clear any fine materials from enclosure. Materials recovered from this process would require additional treatment before they could be disposed of (i.e., microencapsulation).
Water washing and spraying: Application of water sprays or water baths of sufficient temperature, pressure, residence time, agitation, surfactants, acids, bases, and detergents to remove hazardous contaminants from debris surfaces and surface pores or to remove contaminated debris surface layers.	All debris: Treatment to a clean debris surface.[a] Brick, cloth, concrete, paper, pavement, rock, wood: Debris must be no more than 1.2 cm (1/2 in.) in one dimension (i.e., thickness limit,[b] except that this thickness limit may be waived under an ''Equivalent Technology'' approval under 40 CFR 268.42,[c] debris surfaces must be in contact with water solution for at least 15 min.	Brick, cloth, concrete, paper, pavement, rock, wood: Contaminant must be soluble to at least 5% by weight in water solution or 5% by weight in emulsion; if debris is contaminated with a dioxin-listed waste,[d] an ''Equivalent Technology'' approval under 40 CFR 268.42 must be obtained.[c]	Water washing was considered a technology that could be performed in the decontamination facility already planned for the SSSTF. The debris would be removed from the boxes and the operator would spray the debris from a safe distance until it meets the performance standard. This technology would generate a fluid and sludge stream that would be a mixed waste and may require additional treatment

Table 4-2. (continued).

Technology Description	Performance and/or Design and Operating Standard	Contaminant Restrictions	Treatment Process
Macroencapsulation with polymeric organics: Application of surface-coating materials such as polymeric organics (e.g., resins and plastics) to substantially reduce surface exposure to potential leaching media.	Encapsulating material must completely encapsulate debris and be resistant to degradation by the debris and its contaminants and materials into which it may come into contact after placement (leachate, other waste, microbes).	None.	Based on this regulatory definition and additional guidance subsequently provided by the EPA, this technology would consist of placing the container in a mold and injecting a polymeric material into the box and around it to fill the mold. Due to radiological concerns with the debris, the debris would not be removed from the boxes. The use of an organic polymer to encapsulate F-listed waste might be questioned since these organic solvents can degrade polymers; however; it is anticipated that, although the waste carries these codes, it is not likely that, there are detectable amounts of solvents present in the debris.
Macroencapsulation with inorganic materials: Use of a jacket of inert inorganic materials to substantially reduce surface exposure to potential leaching media.	Encapsulating material must completely encapsulate debris and be resistant to degradation by the debris and its contaminants and materials into which it may come into contact after placement (leachate, other waste, microbes).	None.	Like macroencapsulation with polymers, some containers of debris may have to be opened and modified to ensure that the immobilization reagent completely encapsulates the debris. Containers can be used but, cannot be used alone without an immobilization reagent to fill the voids. Cement would be used as an immobilization reagent. Due to radiological concerns with the debris, it is anticipated that the debris would not be removed from the boxes.

Table 4-2. (continued).

Technology Description	Performance and/or Design and Operating Standard	Contaminant Restrictions	Treatment Process
Microencapsulation: This requires stabilization of the debris with the following reagents (or waste reagents) such that the leachability of the hazardous contaminants is reduced: (1) Portland cement or (2) lime/pozzolans (e.g., fly ash and cement kiln dust). Reagents (e.g., iron salts, silicates, and clays) may be added to enhance the set/cure time and/or compressive strength or to reduce the leachability of the hazardous constituents.[b]	Leachability of the hazardous contaminants must be reduced.	None.	Microencapsulation would be very similar to macroencapsulation, except that the outside of the container would not be encased in grout. In addition, there is no requirement for filling all void space. Cement grout will be injected into the box through the liner until the grout fills the box.
Sealing: This requires application of an appropriate material, which adheres tightly to the debris surface to avoid exposure of the surface to potential leaching media. When necessary to seal the surface effectively, sealing entails pretreatment of the debris surface to remove foreign matter and to clean and roughen the surface.	Sealing must avoid exposure of the debris surface to potential leaching media, and sealant must be resistant to degradation by the debris and its contaminants and materials into which it may come into contact after placement (leachate, other waste, microbes).	None.	Sealing would require the construction of an open-air facility to apply the coating. The sealing would be done in an open area to reduce exposure to fumes. Sealing would be done by spraying the debris with a polyurethane coating. Because loose material must be removed from the debris, it is anticipated that this process would require pretreatment with water washing as described in the first alternative and then allowed to dry prior to undergoing the sealing process.

Table 4-2. (continued).

Technology Description	Performance and/or Design and Operating Standard	Contaminant Restrictions	Treatment Process
Sealing materials include epoxy, silicone, and urethane compounds, but paint may not be used as a sealant.			

a. ''Clean debris surface'' means the surface, when viewed without magnification, is free of all visible contaminated soil and hazardous waste except that residual staining from soil and waste consisting of light shadows, slight streaks, or minor discoloration, and soil and waste in cracks, crevices, and pits may be present provided that such staining and waste and soil in cracks, crevices, and pits are limited to no more than 5% of each square inch of surface area.

b. If reducing the particle size of debris to meet the treatment standards results in material that no longer meets the 60 mm minimum particle size limit for debris, such material is subject to the waste-specific treatment standards for the waste contaminating the material, unless the debris has been cleaned and separated from contaminated soil and waste prior to size reduction. At a minimum, simple physical or mechanical means must be used to provide such cleaning and separation of nondebris materials to ensure that the debris surface is free of caked soil, waste, or other nondebris material.

c. The demonstration ''Equivalent Technology'' under 40 CFR 268.42 must document that the technology treats contaminants subject to treatment to a level equivalent to that required by the performance and design and operating standards for other technologies in this table such that residual levels of hazardous contaminants will not pose a hazard to human health and the environment absent management controls.

d. Dioxin-listed wastes are EPA Hazardous Waste numbers F020, F021, F022, F023, F026, and F027.

5. TREATMENT TECHNOLOGY SELECTION

Following the prescreening of the most applicable technologies, an evaluation of the remaining six debris treatment processes was conducted and a specific process was selected through a value engineering session. The value engineering session consisted of developing evaluation criteria, prioritizing the criteria using a pairwise comparison, rating each of the prescreened alternatives based on the criteria, and finally selecting a primary debris treatment process for the SSSTF.

5.1 Evaluation Criteria

Six primary criteria were determined with subcriteria defining the intent of the primary criterion. The six evaluation criteria consist of: (1) quality control, (2) operations, (3) cost, (4) implementability, (5) process risk, and (6) robustness. A description of each of these criteria and the associated subcriteria is provided below.

Criterion 1 - Quality control: This is defined as the ease and ability to meet the performance standard for debris treatment and how well it can be verified. This criterion addresses the effectiveness and consistency. It also evaluates the ability of the technology to provide a reliable and defensible treatment that will generate a high level of confidence in the protectiveness of the end product.

- **Subcriterion 1.1-Ease of process verification:** The ability to document that the performance standards were met.
- **Subcriterion 1.2-Consistency:** This subcriterion addresses the technology consistency in terms of reproducibility and repeatability.

Criterion 2 - Operations: This criterion addresses the operation and maintenance of the alternatives.

- **Subcriterion 2.1-Maintainability:** This subcriterion addresses whether a technology is easy to maintain and is able to keep the equipment running.
- **Subcriterion 2.2-Operability:** This subcriterion addresses how complicated a technology is to operate on a day-to-day basis.
- **Subcriterion 2.3-Reliability:** This is defined as how well the system stays up and running and minimizes downtime.
- **Subcriterion 2.4-Ease of process decontamination.**
- **Subcriterion 2.5-Amount and type of secondary waste generation:** This criterion is evaluated as to the volume and type of secondary waste generated for each considered treatment process.

Criterion 3 - Cost

- **Subcriterion 3.1-Capital costs:** Cost of design and construction.
- **Subcriterion 3.2-Operational and maintenance costs:** These costs include labor (personnel requirements) materials, and addressing secondary waste streams.
- **Subcriterion 3.3-D&D&D closure costs:** This is the cost to shut down and remove the system.

Criterion 4 - Implementability: Ease of implementation.

- **Subcriterion 4.1-Complexity of design.**
- **Subcriterion 4.2-Complexity of construction**: This includes both constructability and how quickly it takes to implement the design.

Criterion 5 - Process risk: This criterion addresses human health and environmental risks.

- **Subcriterion 5.1-Worker exposure:** This includes exposure to both radiological and hazardous materials.
- **Subcriterion 5.2-Environmental risk:** This addresses the possible impacts of the system to the surrounding environment.
- **Subcriterion 5.3-Industrial safety risk**: This addresses the physical risk to workers.

Criterion 6 - Robustness: This criterion addresses the ability of a treatment process to handle a variety of **debris** materials (radiation content, size, and shape).

The criteria were evaluated using Criterium DecisionPlus™ decision analysis software. Each of the six criterion were evaluated pairwise within the DecisionPlus™ software to yield the relative priorities shown in Figure 5-1. These priorities give an indication of the weighting given each of the criteria.

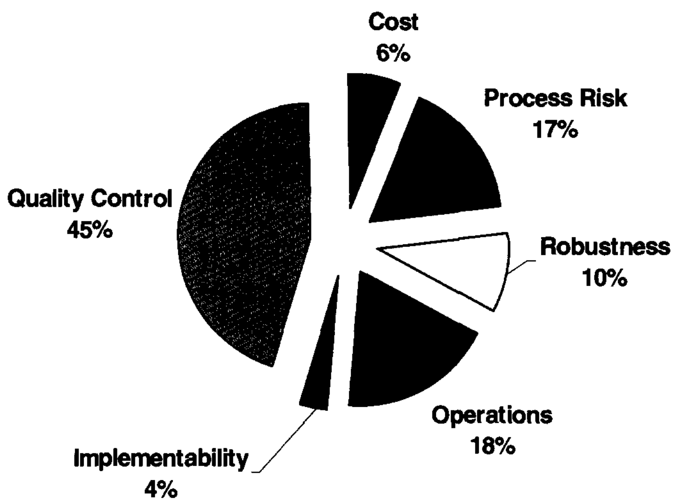

Figure 5-1. Priorities of each of the major criteria used to evaluate the alternatives.

Following the prioritization of the criteria, the ranking of the alternatives was conducted. All six alternatives were considered and ranked for each of the 15 subcriteria and one primary criteria, "robustness" (because no subcriteria were applied), by each member of the value-engineering group. The subcriteria were ranked on a scale of 0 to 10 (with 0 being the least favorable and 10 being the most favorable) based upon collective discussion and subsequent consensus. The ranking for each of the treatment alternatives was then combined with the prioritization of the criteria using the DecisionPlus™ software to determine the selected debris treatment process.

The immobilization technologies scored the highest and the results of the evaluation for these technologies are shown in Figure 5-2. The other three technologies, abrasive blasting, water washing and spraying, and sealing are not shown on the figure because their scores were significantly lower than the immobilization technologies and therefore were not considered viable options for primary treatment. The raw scores of the evaluation for the immobilization technologies were tabulated and are included in Appendix A. The criteria and issues associated with how each of the six treatment technologies meet these criteria is provided in Table 5-1.

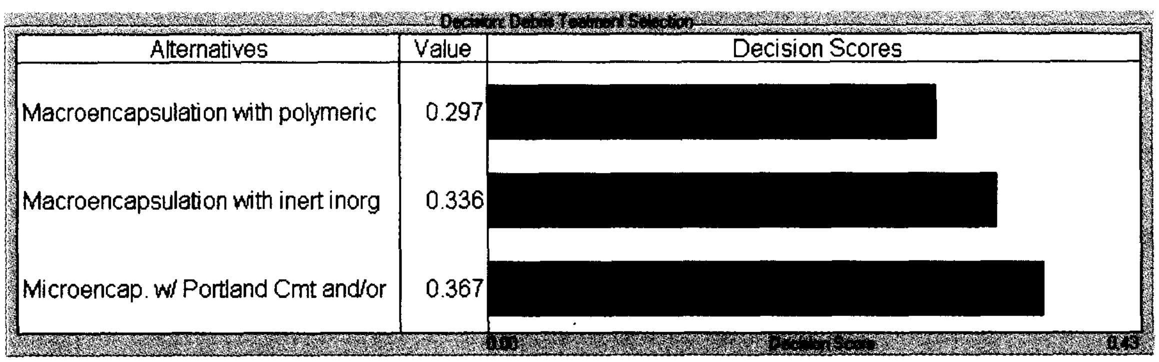

Figure 5-2. Final scoring of the immobilization technologies using the DecisionPlus™ Software.

5.2 Selected Debris Treatment Process

Based upon the comparison of each of the treatments with the six evaluation criteria, microencapsulation with inorganic materials was selected as the primary debris treatment process for the SSSTF. Microencapsulation, as described, is the easiest to perform, least expensive, easily meets the performance standard, and is the safest with the least amount of worker exposure to the hazardous and radioactive contaminants.

Macroencapsulation with inert inorganic material was a potential technology but is more expensive. This technology would also require additional handling of the debris, which would increase exposure, therefore, violating the ALARA concept. Macroencapsulation would also require an intensive quality assurance program to ensure the concrete encapsulating the debris would not crack while curing and during and following placement in the ICDF.

Although water washing and spraying was not selected as the primary treatment option because this technology is limited to only certain types of debris, it could be readily performed in the planned decontamination facility as a pretreatment or supplemental option. It is a supplemental technology, in that it would generate a fluid and sludge stream that would be a mixed waste, and may require additional treatment. It is not a technology that is applicable to debris that has essentially fixed contaminants.

Table 5-1. Debris treatment technology evaluation.

	Debris Treatment Technology					
Evaluation Criteria	Abrasive Blasting	Water Washing and Spraying	Macro-encapsulation With Polymers	Macro-encapsulation With Inorganic Materials	Micro-encapsulation With Inorganic Materials	Sealing
Quality Control: This is the ease and ability to meet the performance standard. It also includes ease of process verification and consistency.	Difficult to verify the performance standard was met on most debris because 0.6 cm of the debris surface is required to be removed.	Easy to do a visual verification for meeting performance standard for a clean surface on select debris. However, most metals of concern in inventory are not water-soluble. Only applicable for select debris and as a pretreatment option.	Somewhat difficult to ensure encapsulation of all the debris inside the box. Also need to ensure polymer mixing is correct.	Somewhat difficult to ensure encapsulation of all of the debris inside the box. Also need to ensure cement mixing is correct and there is no cracking of the concrete monolith during curing and transportation to the ICDF.	Easy to meet performance standard of reduced leachability by injecting grout into box.	Requires intensive visual verification to ensure all surfaces are sealed. Also need to ensure polymer mix is consistent.
Operations: This is the ease and ability to operate and maintain the treatment system. It also includes reliability, ease of decontamination, and secondary waste generation.	Complex and difficult to maintain and operate. Will generate secondary waste that will require treatment.	Easy to maintain and operate. Will generate secondary waste but is only applicable for select debris and as a pretreatment option.	More difficult to maintain and operate due to handling of the polymer materials. Low secondary waste generation.	Easy to maintain and operate. Transportation of concrete monolith following treatment will be difficult due to size and weight. Easy to decontaminate and minimal secondary waste generation.	Reliable and easiest to maintain and operate. Lower weight – easier to transport. Minimal secondary waste generation.	More difficult to maintain and operate due to equipment and handling of hazardous materials. Low secondary waste generation.

Table 5-1. (continued).

	Debris Treatment Technology					
Evaluation Criteria	Abrasive Blasting	Water Washing and Spraying	Macro-encapsulation With Polymers	Macro-encapsulation With Inorganic Materials	Micro-encapsulation With Inorganic Materials	Sealing
Cost: This includes capital, operational and maintenance, and D&D&D closure costs.	High cost for remote handling and additional treatment. Also would require additional enclosure and air filtration requirements.	Low cost because process will be conducted in decontamination building. Only applicable for select debris and as a pretreatment option.	Higher costs associated with polymer and mold – likely more than encapsulation with cement products.	Low cost associated with using cement products and forms.	Lowest cost because treatment only requires grout inside box without special formwork for holding grout.	Higher costs associated with polymer and specialized spraying equipment.
Implementability: This is the ease of design and construction.	Difficult due to remote operation and enclosure requirements, etc.	Easy to implement but only applicable for select debris and a pretreatment option.	Implementation is more intensive than encapsulation with cement products (i.e., product mixing, storage, injection).	Easy to implement because cement is available and easily injected. Forms are easy to construct.	Easiest to implement to meet performance standard. No special equipment or forming.	Will require specialized equipment and storage and handling.
Process Risk: This includes exposure to workers, the environment, and industrial safety factors.	Highest risk due to increased exposure and double handling/treatment of materials.	Some risk because of handling the contaminated debris during washing.	Moderate risk: This will require some handling to ensure encapsulation of all debris. Will also require handling and storing hazardous materials.	Moderate risk: This will require some handling and exposure to ensure encapsulation of all debris.	Lowest risk: No handling is necessary to inject grout into box. Worker contact with debris is not required. ALARA is achieved using this option.	High risk: This will require intensive handling to ensure all surfaces are coated. Will also require handling and storing hazardous materials.
Robustness: This is the ability to handle a variety of debris materials.	Low. Difficult to ensure treatment on all types of debris is consistent.	Low. Only applicable for select debris and as a pretreatment option.	Medium. Treatment is applicable for all types.	Medium. Treatment is applicable for all types.	Medium. Treatment is applicable for all types.	Low. Difficult to ensure treatment on all types of debris is consistent.

For example, it would not be applied to brick, cloth, concrete, paper, pavement, rock, and wood, since it is unlikely that the performance standard could be met. Specifically, it is unlikely that the contaminants present in the WAG 3 debris will have contaminants that are soluble (5% by weight) in an aqueous solution.

Water washing and spraying is, however, a viable option for consideration because it can be utilized without the construction of an additional facility to reduce the volume of waste to be treated. It is considered mostly applicable to debris that has been contaminated with soil that can be removed through washing and is mostly limited to metal or glass items.

6. SELECTED TREATMENT PROCESS DESCRIPTION

As previously stated, microencapsulation with inorganic materials was selected as the primary debris treatment process for the SSSTF. The performance specification for microencapsulation is to reduce the leachability of the hazardous contaminants on the debris. This treatment process will be performed in a nonintrusive, nonlabor-intensive manner to reduce exposure potential to those workers conducting the treatment and is expected to consist of the following steps:

- The box containing the hazardous debris would be placed in the working area.
- Two holes would be cut into each end on the top of the box with a hole saw. The operator will ensure that the holes breach the plastic liner on the inside of the box.
- The nozzle of the grout pump will be inserted into one of the holes in the box and liner and a flowing cement grout will be slowly pumped into the box until the grout rises and begins to come out of the other hole.
- The cement grout would then be allowed to cure. Once cured, a forklift would place the box on a flat bed truck where it would be transported to the ICDF for placement.

Figure 6-1, shown below, is a conceptual drawing of the microencapsulation process. This figure illustrates how holes would be drilled through the top of the braced box into the debris followed by injection of the grout through and around the debris until the box is filled. The following sections describe the cement grout recipes planned for microencapsulating the debris, the design for bracing the debris boxes during treatment, and quality control issues.

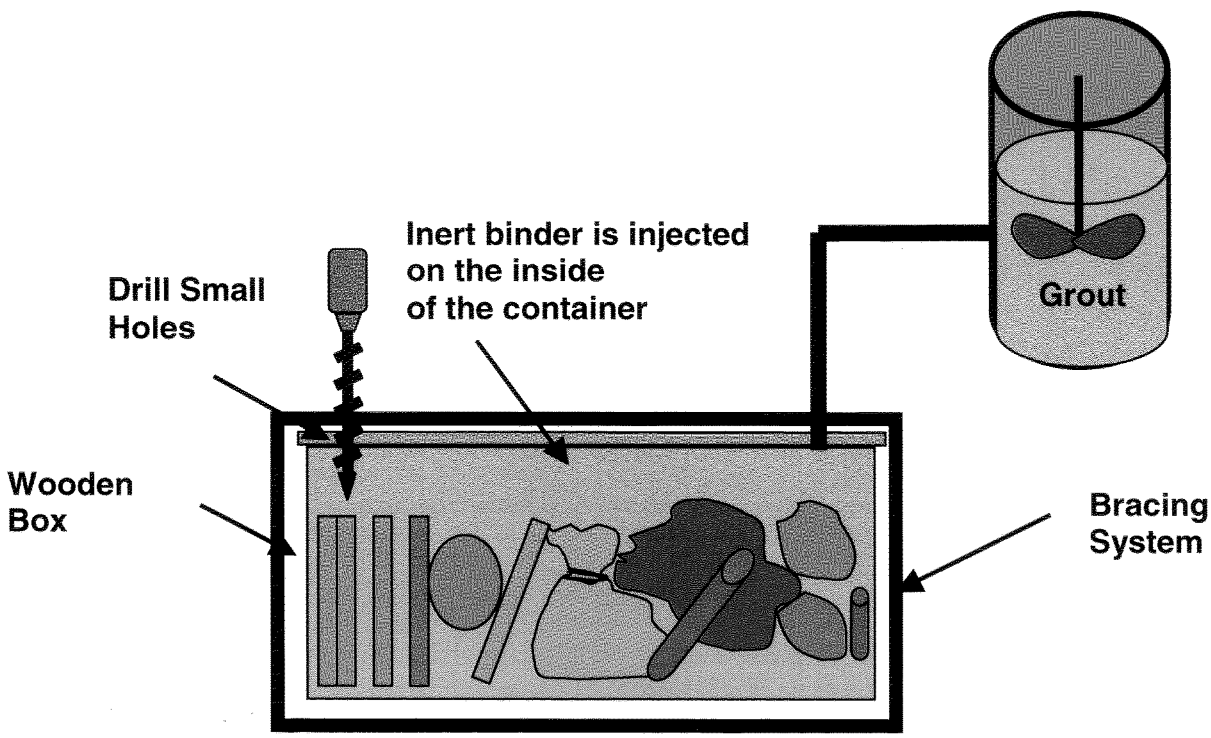

Figure 6-1. Conceptual drawing of the microencapsulation treatment process.

6.1 Grout Mixtures

Portland-cement-based grout will be used for microencapsulation of hazardous debris. A flowable grout is needed in order to fill debris boxes without removal of the box lids or handling of the debris. Other grout properties that are desirable include

- Low quantities of bleed water as setting occurs
- Low shrinkage to minimize cracks and voids
- Adequate strength to minimize potential for cracks during box handling
- Low unit weight, if feasible, in order to minimize the box weight.

Table 6-1 describes the grout mixtures that are proposed for consideration. Mix No. 1 does not include sand. It is very flowable but will have more potential for bleed water, shrinkage, and shrinkage cracks. It has been used for previous projects and its properties are fairly well understood.

Mix No. 2 contains a lightweight fine sand. It has better properties but is less flowable. The mix design is only a starting point for trial mixes. No testing has been performed to verify that the material proportions are appropriate. Tests will be required prior to use of Mix No. 2.

The quantity of water and high range water reducer will vary to adjust the flowability of the grout mixture. The quantity of lightweight sand will need to be adjusted based on the specific gravity of the sand.

Table 6-1. Grout mixes for the debris treatment process.

	Estimated Batch Weights (yd^3)	
Material	Mix. No. 1	Mix No. 2
Water	800 lb (96 gal)	433 lb (52 gal)
Cement (Type I/II)	680 lb	320 lb
Fly ash	1,600 lb	640 lb
Pumic sand	—	1,400 lb
High range water reducer	Approx. 6 lb	Approx. 8 lb

Trial mixes of the grout should be tested in simulated debris boxes to ensure that the grout will flow around the debris as required. The trial mix designs should be tested for strength using ASTM C 39, Test Method for Compressive Strength of Cylindrical Concrete Specimens or C 109, Test Method for Compressive Strength of Hydraulic Cement Mortars. It is recommended that the flowability of the grout mixes be tested using one of the following:

- ASTM C 939, Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
- ASTM D 6449, Flow of Fine Aggregate Concrete for Fabric Formed Concrete (Flow Cone Method).

Observation or measurement of unit weight and bleed water is also recommended for the test mixes. Once the mix designs have been selected, the only required test will be one of the flowability tests.

6.2 Debris Box Bracing

As stated previously, there are two sizes of debris boxes. The INEEL drawing number 410206 gives box dimensions, configuration, and materials. The boxes are approximately 2 ft high × 4 ft × 8 ft or 4 ft high × 4 ft × 8 ft. Preliminary calculations were performed to determine the ability of the boxes to resist the pressures that grouting will impose. A copy of the calculations is attached in Appendix B. The 4-ft-high boxes will require bracing during grouting. The bracing consists of a welded-steel frame connected so that it supports the box exterior. The framing has been designed to accommodate the slight variations in box dimensions. Additionally, the bracing can be reused for numerous boxes. A conceptual drawing of the bracing system for the boxes is shown in Figure 6-2. The design drawings for the bracing system are provided in Appendix C.

The 2-ft-high boxes are adequate to support the pressure from grouting if the glue bonding of the plywood skin to the 2-ft × 4-ft framing is adequate to resist the grout pressure. Otherwise, screws could be installed to ensure the adequacy of the 2-ft-high boxes or the boxes can be shored as identified for the larger boxes.

6.3 Quality Control Issues

Quality control for the microencapsulation process is relatively easy. Contacting the waste inside the box with cement grout will reduce the leachability of the contaminants, thereby meeting the performance standard. It is expected that the process will be easy to perform and will produce consistent results.

Operation of the treatment equipment is straightforward and reliable. The equipment has a proven track record of consistent performance and is easily maintained. Control of direct radiation exposure in this process is easily manageable since the box is never opened, the contaminated material in the box is never handled, and there are no activities, such as sampling, that must be performed manually. Radionuclide confinement in this type of system is expected to be manageable but will rely on building containment.

All of the treated debris will be disposed of in the ICDF, which is a RCRA Subtitle C landfill specifically designed and operated to manage this type of waste. The ICDF performance assessment assumes that all of the debris entering the landfill was not treated.

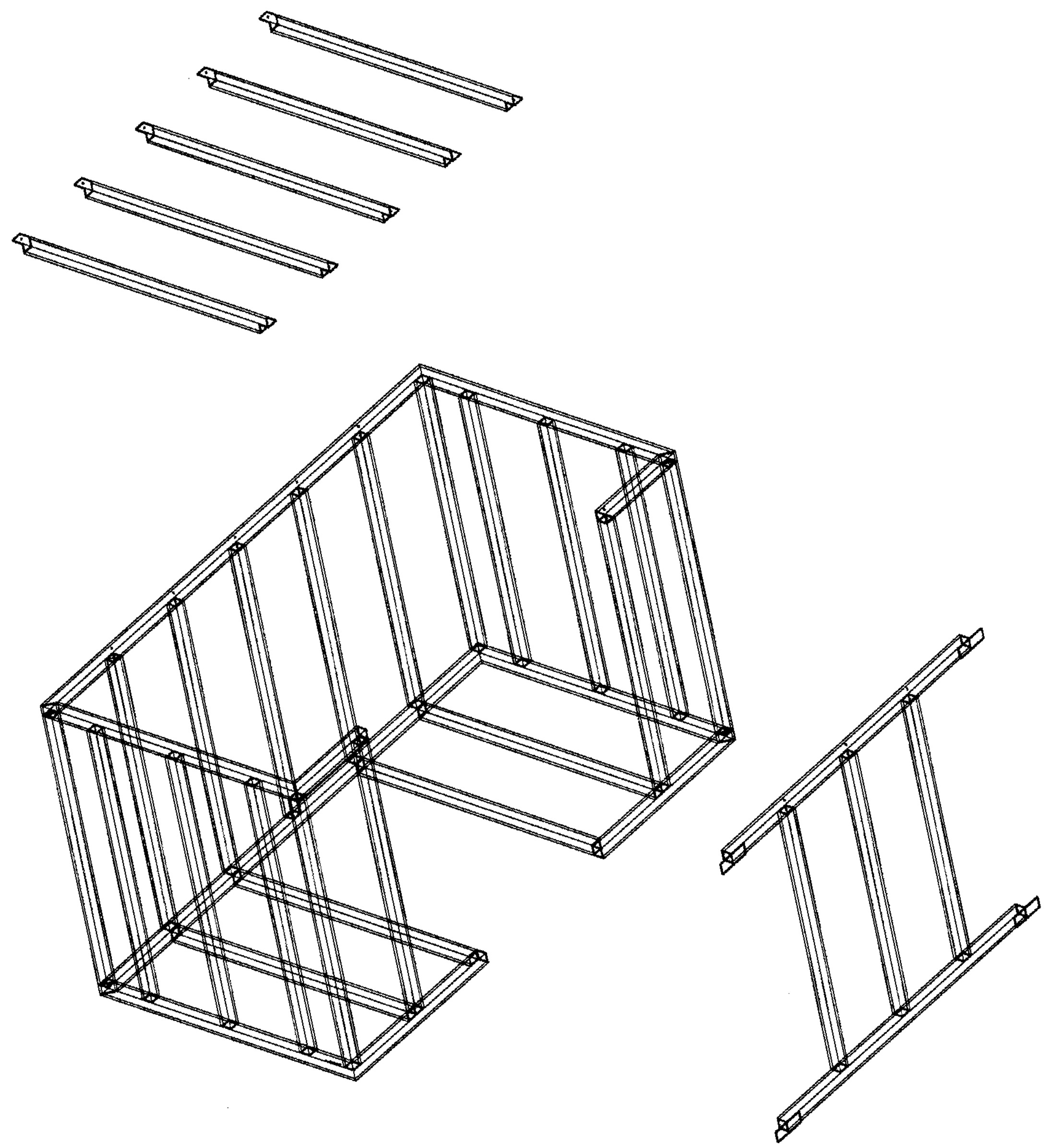

Figure 6-2. Debris treatment box grouting support frame assembly.

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Appendix A

DecisionPlus^{TM} Software Prioritization and Ranking Results for the Immobilization Technologies

Table A-1. Design treatment technology selection–criteria pairwise ranking results.

Rating Set	Weights	Priorities
Quality control	Pairwise	0.455
Operations	Pairwise	0.181
Cost	Pairwise	0.064
Implementability	Pairwise	0.035
Process risk	Pairwise	0.168
Robustness	Pairwise	0.097

Table A-2. Debris treatment technology selection —immobiliation technology rankings.

Criteria	Macroencapsulation with polymeric organics Rating	Macroencapsulation with polymeric organics Priority	Macroencapsulation with inert inorganics Rating	Macroencapsulation with inert inorganics Priority	Microencapsulation with inert inorganics Rating	Microencapsulation with inert inorganics Priority
Quality Control						
Ease of Process Verification	8.78	0.325	8.56	0.317	9.67	0.358
Process Consistency	8.11	0.303	8.67	0.324	10	0.373
Operations						
Maintainability	7	0.276	9	0.355	9.38	0.37
Operability	6.5	0.26	8.75	0.35	9.75	0.39
Reliability	7.63	0.291	8.63	0.329	10	0.381
Ease of Process Decontamination	8.63	0.315	9.75	0.356	9	0.329
Secondary Waste Generation	7.22	0.277	9.11	0.349	9.78	0.375
Cost						
Capital	6.5	0.256	8.88	0.35	10	0.394
Operations & Maintenance	7.13	0.278	8.63	0.337	9.88	0.385
D&D&D	7.25	0.277	9.13	0.349	9.75	0.373
Implementability						
Complexity of Design	6.38	0.26	8.38	0.342	9.75	0.398
Complexity of Construction	6.88	0.274	8.88	0.353	9.38	0.373
Process Risk						
Worker Exposure Risk Reduction	7.56	0.289	9.78	0.374	8.78	0.336
Industrial Safety Risk	6.78	0.274	8.56	0.345	9.44	0.381
Environmental Risk	7.22	0.28	9.33	0.362	9.22	0.358
Robustness	8.56	0.312	9.22	0.336	9.67	0.352

Appendix B

EDF-2693 SSSTF – Waste Box Grouting Frame

Document ID: EDF-2693
Revision ID: 0
Effective Date: 3.07.02

Engineering Design File

PROJECT FILE NO. 020996

Staging, Storage, Sizing and Treatment Facility

Waste Box Grouting Frame

Prepared for:
U.S. Department of Energy
Idaho Operations Office
Idaho Falls, Idaho

INEEL
Idaho National Engineering and Environmental Laboratory

Form 412.14
07/24/2001
Rev. 03

ENGINEERING DESIGN FILE

PROJECT FILE NO.	020996
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PROJECT/TASK SSSTF —— MINIMUM INFRASTRUCTURE

SUBTASK DEBRIS TREATMENT

EDF PAGE NO. 1 OF 7

TITLE **Waste Box Grouting Frame Design Calculations**

SITE AREA INTEC BUILDING NO. ______ SSC IDENTIFICATION/EQUIPMENT NO. ______

SUMMARY

The attached calculations look at the ability of standard debris (waste) boxes (see INEEL drawing 410206) to withstand the pressure imposed if a box is filled with a Portland cement based grout. The EDF also includes design calculations and analyses for a frame to support the waste box during grouting.

Conclusions:

The calculations indicate that the 2 foot high boxes are adequate to support the grout pressures if the nails and glue will withstand the pressures. This EDF did not check the glue or nails since it assumes that an external frame will be used to brace all the boxes. The 4 foot high boxes require added bracing in order to withstand the pressures.

Recommendations:

Provide external bracing for the 4 foot high boxes. An analysis of a frame capable of supporting the box during grouting is included herein.

Use the external bracing designed for the 4 foot high boxes for the 2 foot high boxes. As an alternate, screws could be added to ensure that the box wall plywood is adequately attached to the wood supports.

NPH PERFORMANCE CATEGORY (DOE-STD 1021) ☐ PC-0 ☐ PC-1 ☐ PC-2 ☐ PC-3 ☐ PC-4 ☒ Not Applicable

SAFETY CATEGORY (MCP-540) ☐ Safety Class ☐ Safety Significant ☐ Low Safety Consequence ☒ Consumer Grade ☐ Not Applicable

KEYWORDS (e.g. area, structure no., general subject matter, etc.): box, grouting

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INDEPENDENT PEER REVIEWER M. H. Doornbos, P.E. (CRB Chair)	DATE 3/8/02	BBWI REQUESTOR R. L. Davison	DATE 3/11/02

Purpose

The purpose of these calculations is to determine the ability of a standard wooden waste box to resist loads imposed on it from full grout pressure and to design a frame that will resist these same pressures if the box is not strong enough by itself.

Scope

These calculations are limited to the previously stated purpose. They are specific to the assumptions presented hereafter.

Assumptions

The waste boxes are approximately 4 feet wide and 8 feet long. The exact dimensions are shown on INEEL Drawing Number 410206 (Reference 1).

The calculations assume that the grout pressure is hydrostatic and that the grout will be fluid until the entire box is full. The assumed grout unit weight is as follows:

Grout unit weight: $\gamma g := 120 \cdot pcf$

The following material properties are assumed for the plywood used in the box construction. They are based on the APA Plywood Design Specification (Reference 2) and the box drawing (Reference 1).

Assume Species Group 1 for face ply. $Eply := 1800000 \cdot psi$ See Table 3 in APA spec.

Plywood thickness: $tply := \frac{3}{4} \cdot in$ Assume 1 foot wide section. $bply := 12 \cdot in$

$Aply := bply \cdot tply$ $Aply = 9\,in^2$ $Sply := \frac{bply \cdot tply^2}{6}$ $Sply = 1.12\,in^3$

$Iply := \frac{bply \cdot tply^3}{12}$ $Iply = 0.42\,in^4$

The steel used in the box support frame is assumed to be either ASTM A36 or ASTM A500 grade B.

Additional assumption specific to the calculations are noted in the calculation section.

Acceptance Criteria

The acceptance criteria for the wooden box are based on the Uniform Building Code or the APA Specifications.

The acceptance criteria for strength of the steel box support frame is the AISC Specification for Structural Steel Buildings ASD (Ref. 3). A deflection limit of 1/4 inch maximum was also used in sizing the frame members.

Calculations

(See Reference 1 for box dimensions and materials)

Calculate Grout Pressure: Worst case depth: (height of grout) $hg := 48 \cdot in - \left(\frac{3}{4} + 1.5 + \frac{3}{4}\right) \cdot in$

$hg = 3.75\,ft$

Maximum pressure: $pmax := hg \cdot \gamma g$ $pmax = 450\,psf$

Check Plywood: Allowable stresses are based on APA Plywood Specifications.

Clear span: $Lply := 24 \cdot in - 3.5 \cdot in$ $Lply = 1.71\,ft$

Assume simple span, actual condition multiple span. $wply := pmax \cdot bply$ $wply = 450\,plf$

$$Vply := \frac{wply \cdot Lply}{2} \qquad Mply := \frac{wply \cdot Lply^2}{8} \qquad \Delta ply := \frac{5 \cdot wply \cdot Lply^4}{384 \cdot Eply \cdot Iply}$$

Calculate stresses: $\Delta ply = 0.11\,in$ Okay < 1/4 inch

$$fv := \frac{3 \cdot Vply}{2 \cdot Aply} \qquad fv = 64\,psi$$ less than Fv = 160 psi, Okay

$$fb := \frac{Mply}{Sply} \qquad fb = 1751\,psi$$ greater than Fb = 1650 psi, However simple span assumption is conservative.

If four span assumed and clear span dimension is used
Reference AISC Manual Beam Diagrams -

$$Mply := 0.1071 \cdot wply \cdot Lply^2$$

$$fb := \frac{Mply}{Sply} \qquad fb = 1500\,psi$$ Okay

Check 2x4 Stiffeners: $t := 3.5 \cdot in$ $b := 1.5 \cdot in$

$$A := b \cdot t \qquad A = 5.25\,in^2 \qquad S := \frac{b \cdot t^2}{6} \qquad S = 3.06\,in^3 \qquad I := \frac{b \cdot t^3}{12} \qquad I = 5.36\,in^4$$

$L := hg$ Effective load width: $be := 24 \cdot in$

Reference drawing indicates 2x4s as 1650 psi western woods.

Reference for allowable stresses and E, 1994 UBC Table 23-IA-3. $E := 1500000 \cdot psi$

Calculate shear, moment, and deflection: (AISC Manual, Beam Diagrams Case 2)

$$W := \frac{be \cdot pmax \cdot L}{2} \qquad W = 1687.5\,lbf \qquad V := \frac{2 \cdot W}{3} \qquad M := \frac{2 \cdot W \cdot L}{9 \cdot \sqrt{3}}$$

$$fv := \frac{3 \cdot V}{2 \cdot A} \qquad fv = 321\,psi$$ greater than Fv = 85 psi No Good

$$fb := \frac{M}{S} \qquad fb = 3181\,psi$$ greater than Fb = 1,650 psi No Good

$\Delta := 0.01304 \cdot \frac{W \cdot L^3}{E \cdot I}$ $\Delta = 0.25\,in$ Bracing of 4 foot deep boxes required.

Check 2 foot deep boxes: $L2 := 1 \cdot ft + 10 \cdot in$

$W := \frac{be \cdot \gamma g \cdot L2^2}{2}$ $W = 403\,lbf$ $V := \frac{2 \cdot W}{3}$ $M := \frac{2 \cdot W \cdot L2}{9 \cdot \sqrt{3}}$

$fv := \frac{3 \cdot V}{2 \cdot A}$ $fv = 77\,psi$ less than Fv = 85 psi, Okay

$fb := \frac{M}{S}$ $fb = 372\,psi$ less than Fb = 1,650 psi, Okay

$\Delta := 0.01304 \cdot \frac{W \cdot L2^3}{E \cdot I}$ $\Delta = 0.01\,in$ Bracing of 2 foot deep boxes not required.

However, the adequacy of the box depends on the glue and nails being capable of resisting the tension created by the grout pressure. Use the same external bracing as the 4 foot boxes. Screw could be installed as an alternative to the bracing but this is not recommended.

Preliminary Size for Horizontal Braces/Frames:

Assume 8 foot span - with braces spaced at 1 foot, 1 foot and 2 feet.

$Ls := 8 \cdot ft$

$p1 := \frac{pmax + \frac{hg - 0.5 \cdot ft}{hg} \cdot pmax}{2}$ $p1 = 420\,psf$

$p2 := \frac{hg - 1 \cdot ft}{hg} \cdot pmax$ $p2 = 330\,psf$

$w1 := p1 \cdot 0.5 \cdot ft$ $w1 = 210\,plf$ $w2 := p2 \cdot 1 \cdot ft$ $w2 = 330\,plf$ w2 governs

$Mmax := \frac{w2 \cdot Ls^2}{8}$ $Mmax = 2.64\,kip \cdot ft$ Assume Fb = 22 ksi

$Sreqd := \frac{Mmax}{22 \cdot ksi}$ $Sreqd = 1.44\,in^3$ C4x5.4, Sx = 1.93 in^3, however deflection may be excessive.

$I1 := 3.85 \cdot in^4$ $Es := 29000000 \cdot psi$

$\Delta s := \frac{5 \cdot w2 \cdot Ls^4}{384 \cdot Es \cdot I1}$ $\Delta s = 0.27\,in$

Deflection approximately 1/4 inch. OKAY

Preliminary Size for Vertical Braces/Frames:

Assume box type bracing with vertical braces @ 20" oc. $L = 3.75\text{ft}$

Calculate shear, moment, and deflection: (AISC Manual, Beam Diagrams Case 2)

$$W := \frac{20 \cdot in \cdot pmax \cdot L}{2} \qquad W = 1406.25\,lbf \qquad V := \frac{2 \cdot W}{3} \qquad M := \frac{2 \cdot W \cdot L}{9 \cdot \sqrt{3}}$$

Try HSS 2x2x3/16 $\quad Av := 2 \cdot 2 \cdot in \cdot \frac{3}{16} \cdot in \quad S2 := 0.668 \cdot in^3 \quad I2 := 0.668 \cdot in^4$

$$fv := \frac{V}{Av} \qquad fv = 1.25\,ksi \qquad fb := \frac{M}{S2} \qquad fb = 12154\,psi \qquad V = 937.5\,lbf$$

$$\Delta := 0.01304 \cdot \frac{W \cdot L^3}{Es \cdot I2} \qquad \Delta = 0.09\,in$$

This concept okay

$$Rtop := \frac{W}{3} \qquad Rtop = 468.75\,lbf \qquad Rbottom := \frac{2 \cdot W}{3} \qquad Rbottom = 937.5\,lbf$$

Final Sizing of Waste Box Grouting Support Framing:

The grouting support framing final design used Multiframe 4D and Steel Designer. Input and selected output from the programs is attached in Appendix A. The Steel Designer check output for the most highly stressed members is included.

The maximum combined stress ratio in any member of the framing model was 0.396 or approximately 60% under the load demand on the member.

A spreadsheet that calculates loading on the members of the model is included in Appendix A. The spreadsheet uses the same assumptions and formulas as the "Preliminary Size for Vertical Braces/Frames" section.

Inner Frame Bolt Bracket:

A inner frame is pushed up against the waste box in order to provide support and still allow the box to be inserted in the framing. The brackets that are used to support and move the inner frame consist of 1/2" plate and 3/8" A307 bolts. The strength and deflection of the 1/2" plate was checked using a finite element model in COSMOS M (Ref. 9). Output showing the stress contours are included herein.

Thinner plates were also checked (1/4" and 3/8" thick). A 3/8" thick plate could be used. However, it would have less thread engagement for the bolt and it was decided to use the 1/2" plate.

Conclusions

Bracing of the 4 foot deep boxes is required.

Bracing of the 2 foot deep boxes is not required if the adequacy of the glue and screw used for the box construction can be verified.

The frame designed as part of this EDF will support the boxes during grouting.

Recommendations

It is recommended that the frame design included as part of this EDF be used to support the boxes during grouting operations. See the attached preliminary drawings for the frame configuration.

References

1. INEEL Drawing Number 410206, RWMC Radioactive Waste Storage 12,800 lb Capacity 2x4x8 and 4x4x8 Plywood Box Assemblies.

2. Preliminary drawings S-1 and S-2, INTEC SSSTF Phase 1, Minimum Infrastructure Debris Treatment, Waste Box Grouting Frame.

3. AISC Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design, June 1989.

4. AISC Manual of Steel Construction, Allowable Stress Design, Ninth Edition.

5. APA Plywood Design Specification, January 1997.

6. Uniform Building Code (UBC), 1994 Edition.

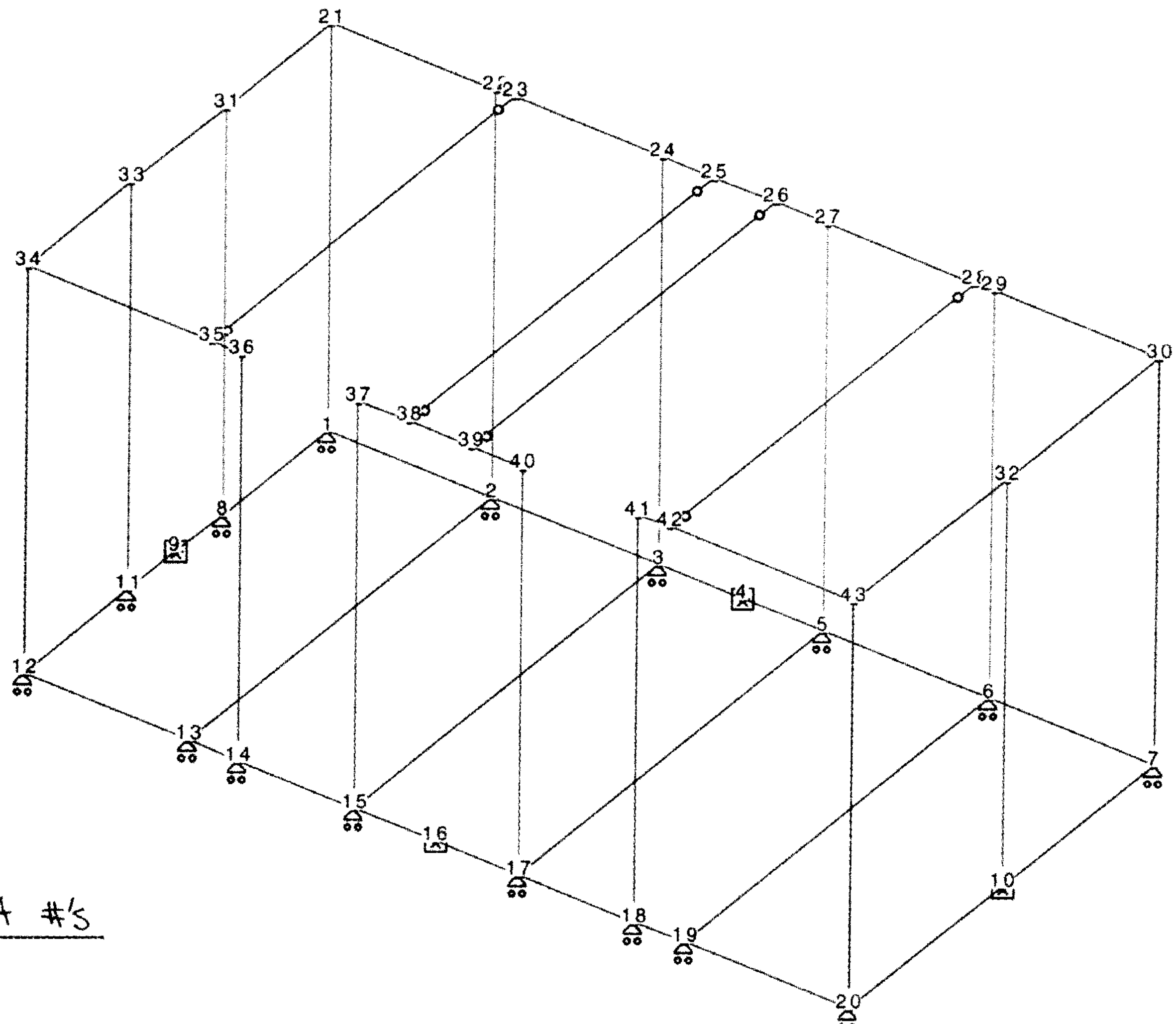
7. Multiframe 4D, Version 5.2, Daystar Software.

8. Steel Designer, Version 5.2, Daystar Software.

9. COSMOS M, Version 2.6, Structural Research & Analysis Corp.

Appendix A

Multiframe and Steel Designer Input and Selected Output


21
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8
41
42
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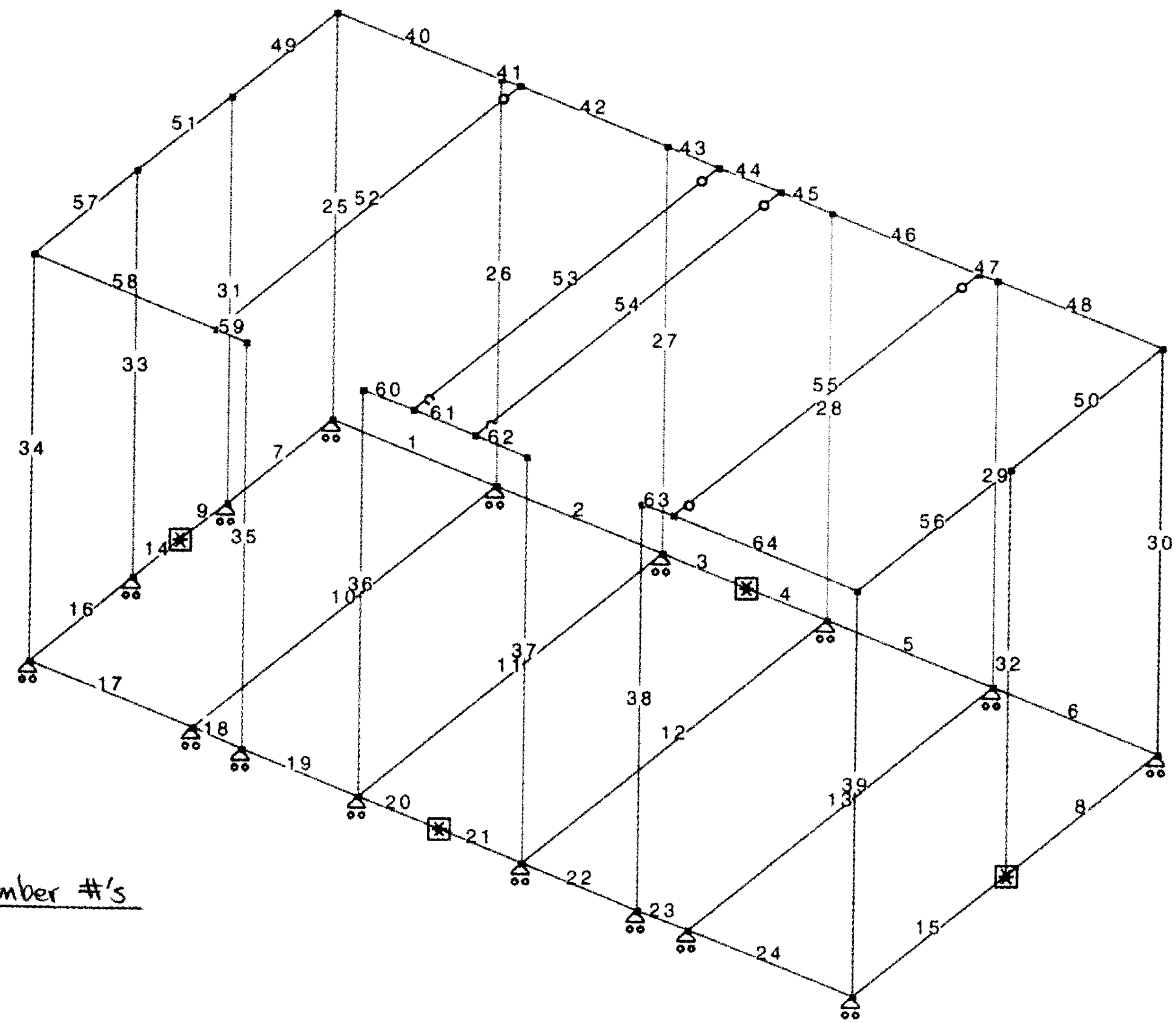
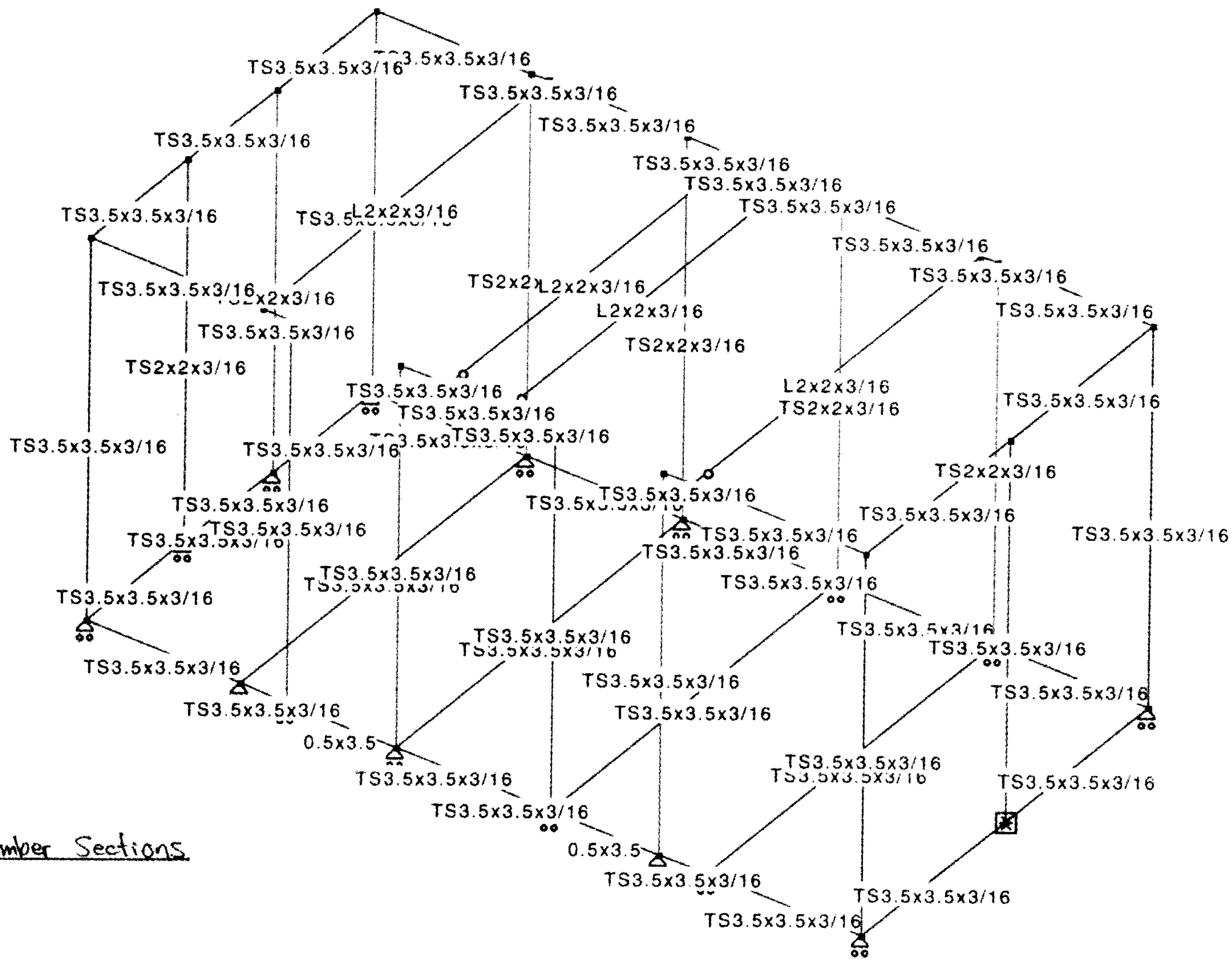
20

Joint #'s


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64

Member #'s



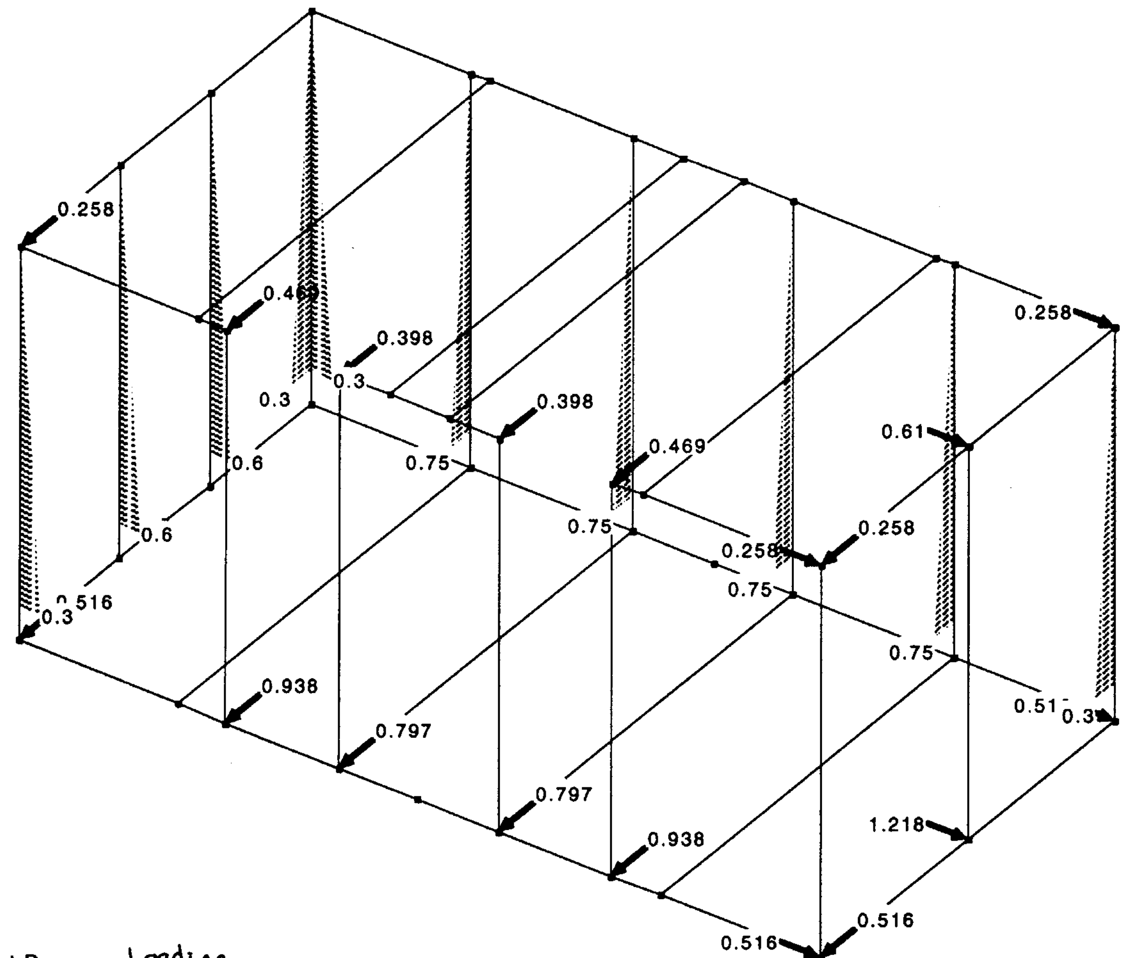
Member Sections

Multiframe Model Loading Spreadsheet

Grout unit weight:	yg =	120	pcf
Height of grout:	hg =	3.75	ft
Maximum pressure:	pmax =	450	psf
	W =	843.75	plf

	Support cntr to cntr spacing (in)	Pressure at bottom (plf)	W (lbs)	R1 (lbs)	R2 (lbs)
Back wall	8	300	563	188	375
	20	750	1406	469	938
	20	750	1406	469	938
	20	750	1406	469	938
	20	750	1406	469	938
	8	300	563	188	375
		3,600	6,750	2,250	4,500
Front wall	11	412.5	773	258	516
	20	750.0	1406	469	938
	17	637.5	1195	398	797
	17	637.5	1195	398	797
	20	750.0	1406	469	938
	11	412.5	773	258	516
		3,600	6,750	2,250	4,500
End wall #1	8	300	563	188	375
	16	600	1125	375	750
	16	600	1125	375	750
	8	300	563	188	375
		1,800	3,375	1,125	2,250
End wall #2	11	412.5	773	258	516
	13	487.5	914	305	609
	13	487.5	914	305	609
	11	412.5	773	258	516
		1,800	3,375	1,125	2,250

End wall	48	1,800	3,375	1,125	2,250
Front or back wall	96	3,600	6,750	2,250	4,500



Grout Pressure Loading

Joint Coordinates (in)

Joint	x	y	z	Type
1	-50.000	0.000	-26.000	Rigid
2	-30.000	0.000	-26.000	Rigid
3	-10.000	0.000	-26.000	Rigid
4	0.000	0.000	-26.000	Rigid
5	10.000	0.000	-26.000	Rigid
6	30.000	0.000	-26.000	Rigid
7	50.000	0.000	-26.000	Rigid
8	-50.000	0.000	-8.000	Rigid
9	-50.000	0.000	-0.000	Rigid
10	50.000	0.000	0.000	Rigid
11	-50.000	0.000	8.000	Rigid
12	-50.000	0.000	26.000	Rigid
13	-30.000	0.000	26.000	Rigid
14	-24.000	0.000	26.000	Rigid
15	-10.000	0.000	26.000	Rigid
16	0.000	0.000	26.000	Rigid
17	10.000	0.000	26.000	Rigid
18	24.000	0.000	26.000	Rigid
19	30.000	0.000	26.000	Rigid
20	50.000	0.000	26.000	Rigid
21	-50.000	49.500	-26.000	Rigid
22	-30.000	49.500	-26.000	Rigid
23	-27.750	49.500	-26.000	Rigid
24	-10.000	49.500	-26.000	Rigid
25	-3.750	49.500	-26.000	Rigid
26	3.750	49.500	-26.000	Rigid
27	10.000	49.500	-26.000	Rigid
28	27.750	49.500	-26.000	Rigid
29	30.000	49.500	-26.000	Rigid
30	50.000	49.500	-26.000	Rigid
31	-50.000	49.500	-8.000	Rigid
32	50.000	49.500	0.000	Rigid
33	-50.000	49.500	8.000	Rigid
34	-50.000	49.500	26.000	Rigid
35	-27.750	49.500	26.000	Rigid
36	-24.000	49.500	26.000	Rigid
37	-10.000	49.500	26.000	Rigid
38	-3.750	49.500	26.000	Rigid
39	3.750	49.500	26.000	Rigid
40	10.000	49.500	26.000	Rigid
41	24.000	49.500	26.000	Rigid
42	27.750	49.500	26.000	Rigid
43	50.000	49.500	26.000	Rigid

Member Geometry (in,deg)

Member	Joint 1	Joint 2	Length	Slope	Orient.
1	1	2	20.000	0.000	0.000
2	2	3	20.000	0.000	0.000
3	3	4	10.000	0.000	0.000
4	4	5	10.000	0.000	0.000
5	5	6	20.000	0.000	0.000
6	6	7	20.000	0.000	0.000
7	8	1	18.000	0.000	0.000
8	10	7	26.000	0.000	0.000
9	9	8	8.000	0.000	0.000
10	13	2	52.000	0.000	0.000
11	15	3	52.000	0.000	0.000
12	17	5	52.000	0.000	0.000

13	19	6	52.000	0.000	0.000
14	11	9	8.000	0.000	0.000
15	20	10	26.000	0.000	0.000
16	12	11	18.000	0.000	0.000
17	12	13	20.000	0.000	0.000
18	13	14	6.000	0.000	0.000
19	14	15	14.000	0.000	0.000
20	15	16	10.000	0.000	0.000
21	16	17	10.000	0.000	0.000
22	17	18	14.000	0.000	0.000
23	18	19	6.000	0.000	0.000
24	19	20	20.000	0.000	0.000
25	1	21	49.500	90.000	0.000
26	2	22	49.500	90.000	0.000
27	3	24	49.500	90.000	0.000
28	5	27	49.500	90.000	0.000
29	6	29	49.500	90.000	0.000
30	7	30	49.500	90.000	0.000
31	8	31	49.500	90.000	0.000
32	10	32	49.500	90.000	0.000
33	11	33	49.500	90.000	0.000
34	12	34	49.500	90.000	0.000
35	14	36	49.500	90.000	0.000
36	15	37	49.500	90.000	0.000
37	17	40	49.500	90.000	0.000
38	18	41	49.500	90.000	0.000
39	20	43	49.500	90.000	0.000
40	21	22	20.000	0.000	0.000
41	22	23	2.250	0.000	0.000
42	23	24	17.750	0.000	0.000
43	24	25	6.250	0.000	0.000
44	25	26	7.500	0.000	0.000
45	26	27	6.250	0.000	0.000
46	27	28	17.750	0.000	0.000
47	28	29	2.250	0.000	0.000
48	29	30	20.000	0.000	0.000
49	31	21	18.000	0.000	0.000
50	32	30	26.000	0.000	0.000
51	33	31	16.000	0.000	0.000
52	35	23	52.000	0.000	0.000
53	38	25	52.000	0.000	0.000
54	39	26	52.000	0.000	90.000
55	42	28	52.000	0.000	90.000
56	43	32	26.000	0.000	0.000
57	34	33	18.000	-0.000	0.000
58	34	35	22.250	0.000	0.000
59	35	36	3.750	0.000	0.000
60	37	38	6.250	0.000	0.000
61	38	39	7.500	0.000	0.000
62	39	40	6.250	0.000	0.000
63	41	42	3.750	0.000	0.000
64	42	43	22.250	0.000	0.000

Member Types

Member	Øx'	Øy'	Øz'	Self Weight
1	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
2	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
3	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
4	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
5	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
6	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic

7	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
8	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
9	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
10	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
11	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
12	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
13	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
14	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
15	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
16	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
17	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
18	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
19	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
20	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
21	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
22	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
23	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
24	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
25	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
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27	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
28	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
29	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
30	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
31	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
32	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
33	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
34	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
35	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
36	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
37	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
38	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
39	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
40	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
41	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
42	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
43	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
44	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
45	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
46	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
47	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
48	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
49	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
50	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
51	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
52	Rigid/Rigid	Pin/Pin	Pin/Pin	Static & Dynamic
53	Rigid/Rigid	Pin/Pin	Pin/Pin	Static & Dynamic
54	Rigid/Rigid	Pin/Pin	Pin/Pin	Static & Dynamic
55	Rigid/Rigid	Pin/Pin	Pin/Pin	Static & Dynamic
56	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
57	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
58	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
59	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
60	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
61	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
62	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
63	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic
64	Rigid/Rigid	Rigid/Rigid	Rigid/Rigid	Static & Dynamic

Member Sections

Member	Group	Section

1	Sq. Tube	TS3.5x3.5x3/16
2	Sq. Tube	TS3.5x3.5x3/16
3	Sq. Tube	TS3.5x3.5x3/16
4	Sq. Tube	TS3.5x3.5x3/16
5	Sq. Tube	TS3.5x3.5x3/16
6	Sq. Tube	TS3.5x3.5x3/16
7	Sq. Tube	TS3.5x3.5x3/16
8	Sq. Tube	TS3.5x3.5x3/16
9	Sq. Tube	TS3.5x3.5x3/16
10	Sq. Tube	TS3.5x3.5x3/16
11	Sq. Tube	TS3.5x3.5x3/16
12	Sq. Tube	TS3.5x3.5x3/16
13	Sq. Tube	TS3.5x3.5x3/16
14	Sq. Tube	TS3.5x3.5x3/16
15	Sq. Tube	TS3.5x3.5x3/16
16	Sq. Tube	TS3.5x3.5x3/16
17	Sq. Tube	TS3.5x3.5x3/16
18	Sq. Tube	TS3.5x3.5x3/16
19	Custom3	0.5x3.5
20	Sq. Tube	TS3.5x3.5x3/16
21	Sq. Tube	TS3.5x3.5x3/16
22	Custom3	0.5x3.5
23	Sq. Tube	TS3.5x3.5x3/16
24	Sq. Tube	TS3.5x3.5x3/16
25	Sq. Tube	TS3.5x3.5x3/16
26	Sq. Tube	TS2x2x3/16
27	Sq. Tube	TS2x2x3/16
28	Sq. Tube	TS2x2x3/16
29	Sq. Tube	TS2x2x3/16
30	Sq. Tube	TS3.5x3.5x3/16
31	Sq. Tube	TS2x2x3/16
32	Sq. Tube	TS3.5x3.5x3/16
33	Sq. Tube	TS2x2x3/16
34	Sq. Tube	TS3.5x3.5x3/16
35	Sq. Tube	TS3.5x3.5x3/16
36	Sq. Tube	TS3.5x3.5x3/16
37	Sq. Tube	TS3.5x3.5x3/16
38	Sq. Tube	TS3.5x3.5x3/16
39	Sq. Tube	TS3.5x3.5x3/16
40	Sq. Tube	TS3.5x3.5x3/16
41	Sq. Tube	TS3.5x3.5x3/16
42	Sq. Tube	TS3.5x3.5x3/16
43	Sq. Tube	TS3.5x3.5x3/16
44	Sq. Tube	TS3.5x3.5x3/16
45	Sq. Tube	TS3.5x3.5x3/16
46	Sq. Tube	TS3.5x3.5x3/16
47	Sq. Tube	TS3.5x3.5x3/16
48	Sq. Tube	TS3.5x3.5x3/16
49	Sq. Tube	TS3.5x3.5x3/16
50	Sq. Tube	TS3.5x3.5x3/16
51	Sq. Tube	TS3.5x3.5x3/16
52	Angle	L2x2x3/16
53	Angle	L2x2x3/16
54	Angle	L2x2x3/16
55	Angle	L2x2x3/16
56	Sq. Tube	TS3.5x3.5x3/16
57	Sq. Tube	TS3.5x3.5x3/16
58	Sq. Tube	TS3.5x3.5x3/16
59	Sq. Tube	TS3.5x3.5x3/16
60	Sq. Tube	TS3.5x3.5x3/16
61	Sq. Tube	TS3.5x3.5x3/16
62	Sq. Tube	TS3.5x3.5x3/16

63	Sq. Tube	TS3.5x3.5x3/16
64	Sq. Tube	TS3.5x3.5x3/16

Section Properties

Section	A	Ix	Iy	J	E	G
	in^2	in^4	in^4	in^4	ksi	ksi
L2x2x3/16	0.715	0.272	0.272	0.009	2.900e+4	1.115e+4
TS3.5x3.5x3/16	2.390	4.290	4.290	6.989	2.900e+4	1.115e+4
TS2x2x3/16	1.270	0.668	0.668	1.150	2.900e+4	1.115e+4
0.5x3.5	0.875	0.005	0.893	0.017	2.900e+4	1.115e+4

Total Mass (lb) 974.779

Joint Restraints and Prescribed Displacements (in,deg)

Joint	dx	dy	dz	Øx	Øy	Øz
1	****	0.000	****	****	****	****
2	****	0.000	****	****	****	****
6	****	0.000	****	****	****	****
7	****	0.000	****	****	****	****
12	****	0.000	****	****	****	****
13	****	0.000	****	****	****	****
14	****	0.000	****	****	****	****
18	****	0.000	****	****	****	****
19	****	0.000	****	****	****	****
20	****	0.000	****	****	****	****
10	****	0.000	0.000	****	****	****
9	****	0.000	0.000	****	****	****
8	****	0.000	****	****	****	****
11	****	0.000	****	****	****	****
3	****	0.000	****	****	****	****
5	****	0.000	****	****	****	****
15	****	0.000	****	****	****	****
17	****	0.000	****	****	****	****
4	0.000	0.000	****	****	****	****
16	0.000	0.000	****	****	****	****

There are no springs

Joint Loads(kip,kip-ft) Grout Pressure

Joint	Px	Py	Pz	Mx	My	Mz
34	-	-	0.258	-	-	-
43	-	-	0.258	-	-	-
12	-	-	0.516	-	-	-
20	-	-	0.516	-	-	-
36	-	-	0.469	-	-	-
41	-	-	0.469	-	-	-
14	-	-	0.938	-	-	-
18	-	-	0.938	-	-	-
37	-	-	0.398	-	-	-
40	-	-	0.398	-	-	-
30	0.258	-	-	-	-	-
43	0.258	-	-	-	-	-
7	0.516	-	-	-	-	-
20	0.516	-	-	-	-	-
32	0.610	-	-	-	-	-
10	1.218	-	-	-	-	-
15	-	-	0.797	-	-	-
17	-	-	0.797	-	-	-

Member Loads (kip,kip-ft) Grout Pressure

Member	Load Type	Left Dist	Right Dist	Left Mag	Right Mag
26	Wz	4.500	0.000	-0.750	-0.000
27	Wz	4.500	0.000	-0.750	-0.000
28	Wz	4.500	0.000	-0.750	-0.000
29	Wz	4.500	0.000	-0.750	-0.000
30	Wz	4.500	0.000	-0.300	-0.000
25	Wx	4.500	0.000	-0.300	-0.000
34	Wx	4.500	0.000	-0.300	-0.000
25	Wz	4.500	0.000	-0.300	-0.000
31	Wx	4.500	0.000	-0.600	-0.000
33	Wx	4.500	0.000	-0.600	-0.000

There are no thermal loads in Grout Pressure

Joint Displacements (in,deg)

Joint	Load Case	dx	dy	dz	Øx	Øy	Øz
1	Grout Pressure	-0.001	0.000	-0.000	-0.011	-0.022	0.019
2	Grout Pressure	-0.000	0.000	0.001	-0.045	0.004	-0.005
3	Grout Pressure	-0.000	0.000	0.001	-0.055	-0.002	0.001
4	Grout Pressure	0.000	0.000	0.001	-0.055	0.000	-0.000
5	Grout Pressure	0.000	0.000	0.001	-0.055	0.002	0.000
6	Grout Pressure	0.000	0.000	0.001	-0.045	-0.003	0.000
7	Grout Pressure	0.001	0.000	-0.000	-0.014	0.021	0.000
8	Grout Pressure	-0.011	0.000	-0.000	0.002	-0.023	0.092
9	Grout Pressure	-0.012	0.000	0.000	-0.000	-0.001	0.095
10	Grout Pressure	0.013	0.000	0.000	0.004	0.002	-0.009
11	Grout Pressure	-0.011	0.000	0.000	-0.000	0.022	0.098
12	Grout Pressure	-0.002	0.000	0.000	0.002	0.018	0.034
13	Grout Pressure	-0.001	0.000	0.001	0.017	-0.014	-0.007
14	Grout Pressure	-0.001	0.000	0.003	0.018	-0.015	0.009
15	Grout Pressure	-0.000	0.000	0.002	0.025	0.004	-0.000
16	Grout Pressure	0.000	0.000	0.001	0.025	0.000	-0.000
17	Grout Pressure	0.000	0.000	0.002	0.025	-0.004	0.000
18	Grout Pressure	0.001	0.000	0.003	0.017	0.015	-0.007
19	Grout Pressure	0.001	0.000	0.001	0.017	0.013	0.004
20	Grout Pressure	0.002	0.000	0.000	0.001	-0.017	-0.014
21	Grout Pressure	-0.003	0.000	0.002	0.021	-0.046	-0.014
22	Grout Pressure	-0.003	-0.000	0.013	0.116	-0.021	0.003
23	Grout Pressure	-0.003	-0.000	0.014	0.120	-0.020	0.002
24	Grout Pressure	-0.003	0.000	0.018	0.158	-0.010	0.000
25	Grout Pressure	-0.003	0.000	0.019	0.158	-0.005	-0.000
26	Grout Pressure	-0.002	0.000	0.019	0.158	0.006	-0.000
27	Grout Pressure	-0.002	-0.000	0.018	0.158	0.012	-0.000
28	Grout Pressure	-0.002	-0.000	0.013	0.121	0.021	0.000
29	Grout Pressure	-0.002	0.000	0.012	0.116	0.022	0.000
30	Grout Pressure	-0.002	0.000	0.001	0.023	0.044	0.001
31	Grout Pressure	-0.020	-0.001	0.002	-0.004	-0.053	-0.057
32	Grout Pressure	0.021	-0.000	0.001	-0.004	0.038	-0.008
33	Grout Pressure	-0.032	0.000	0.002	-0.001	-0.026	-0.053
34	Grout Pressure	-0.037	-0.000	0.002	0.003	-0.019	-0.002
35	Grout Pressure	-0.037	-0.001	0.015	0.012	-0.040	0.012
36	Grout Pressure	-0.037	0.000	0.017	0.013	-0.041	0.022
37	Grout Pressure	-0.000	-0.000	0.021	0.021	0.008	-0.000
38	Grout Pressure	-0.000	-0.000	0.020	0.021	0.005	-0.000
39	Grout Pressure	-0.000	-0.000	0.020	0.021	-0.004	0.000
40	Grout Pressure	-0.000	0.000	0.021	0.021	-0.007	0.000
41	Grout Pressure	0.031	0.000	0.017	0.013	0.040	-0.014

42	Grout Pressure	0.031	-0.000	0.014	0.011	0.040	-0.005
43	Grout Pressure	0.031	-0.000	0.002	0.003	0.021	-0.012

Joint Reactions (kip,kip-ft)

Joint	Load Case	Rx	Ry	Rz	Mx	My	Mz
1	Grout Pressure	0.000	0.179	0.000	-0.000	0.000	-0.000
2	Grout Pressure	-0.000	-0.209	0.000	-0.000	0.000	0.000
3	Grout Pressure	-0.000	0.339	-0.000	0.000	0.000	-0.000
4	Grout Pressure	0.005	-0.102	0.000	0.000	0.000	0.000
5	Grout Pressure	0.000	0.168	0.000	0.000	-0.000	-0.000
6	Grout Pressure	-0.000	0.142	0.000	-0.000	-0.000	0.000
7	Grout Pressure	0.000	-0.131	0.000	0.000	0.000	-0.000
8	Grout Pressure	-0.000	-0.217	-0.000	0.000	-0.000	0.000
9	Grout Pressure	0.000	0.400	0.002	0.000	0.000	0.000
10	Grout Pressure	0.000	0.043	-0.004	0.000	0.000	0.000
11	Grout Pressure	-0.000	-0.220	-0.000	0.000	-0.000	-0.000
12	Grout Pressure	0.000	1.293	0.000	0.000	-0.000	0.000
13	Grout Pressure	0.000	-0.435	0.000	0.000	-0.000	0.000
14	Grout Pressure	-0.000	-0.892	0.000	-0.000	0.000	-0.000
15	Grout Pressure	0.000	-0.148	-0.000	-0.000	-0.000	-0.000
16	Grout Pressure	-0.006	0.012	0.000	0.000	0.000	0.000
17	Grout Pressure	-0.000	-0.151	0.000	-0.000	0.000	-0.000
18	Grout Pressure	0.000	-1.374	0.000	0.000	-0.000	-0.000
19	Grout Pressure	0.000	0.463	0.000	0.000	0.000	-0.000
20	Grout Pressure	-0.000	0.839	-0.000	0.000	-0.000	0.000
21	Grout Pressure	0.000	0.000	0.000	-0.000	-0.000	-0.000
22	Grout Pressure	-0.000	-0.000	0.000	0.000	0.000	0.000
23	Grout Pressure	0.000	0.000	0.000	0.000	0.000	-0.000
24	Grout Pressure	-0.000	0.000	-0.000	-0.000	-0.000	0.000
25	Grout Pressure	0.000	0.000	0.000	0.000	0.000	0.000
26	Grout Pressure	0.000	0.000	0.000	0.000	0.000	0.000
27	Grout Pressure	0.000	0.000	-0.000	-0.000	0.000	0.000
28	Grout Pressure	0.000	0.000	0.000	0.000	0.000	0.000
29	Grout Pressure	0.000	-0.000	0.000	0.000	-0.000	0.000
30	Grout Pressure	0.000	-0.000	0.000	0.000	-0.000	0.000
31	Grout Pressure	0.000	0.000	-0.000	-0.000	0.000	0.000
32	Grout Pressure	0.000	0.000	0.000	0.000	0.000	0.000
33	Grout Pressure	-0.000	-0.000	-0.000	0.000	0.000	-0.000
34	Grout Pressure	-0.000	0.000	0.000	0.000	-0.000	-0.000
35	Grout Pressure	0.000	0.000	0.000	0.000	0.000	-0.000
36	Grout Pressure	0.000	0.000	-0.000	0.000	0.000	0.000
37	Grout Pressure	0.000	0.000	0.000	0.000	0.000	0.000
38	Grout Pressure	0.000	0.000	-0.000	0.000	0.000	-0.000
39	Grout Pressure	0.000	0.000	-0.000	0.000	0.000	-0.000
40	Grout Pressure	0.000	0.000	0.000	0.000	0.000	0.000
41	Grout Pressure	0.000	0.000	0.000	0.000	0.000	0.000
42	Grout Pressure	0.000	0.000	-0.000	0.000	0.000	-0.000
43	Grout Pressure	-0.000	-0.000	0.000	0.000	0.000	-0.000

Sum of Reactions (kip,kip-ft) Grout Pressure

Rx	-0.001
Ry	0.000
Rz	-0.002
Mx	1.688
My	-0.000
Mz	-0.840

Member Actions (kip,kip-ft)

Member	Load Case	Px'	Vy'	Vz'	Tx'	My'	Mz'
1	Grout Pressure	-1.051	0.463	0.416	0.192	-0.582	0.602
		1.051	-0.463	-0.416	-0.192	-0.112	0.170
2	Grout Pressure	-1.018	-0.126	-0.095	0.057	0.128	-0.158

		1.018	0.126	0.095	-0.057	0.030	-0.053
3	Grout Pressure	-1.032	0.087	0.002	0.001	-0.036	0.058
		1.032	-0.087	-0.002	-0.001	0.034	0.014
4	Grout Pressure	-1.027	-0.015	0.002	0.001	-0.034	-0.014
		1.027	0.015	-0.002	-0.001	0.032	0.002
5	Grout Pressure	-1.023	0.009	0.093	-0.053	-0.029	0.008
		1.023	-0.009	-0.093	0.053	-0.126	0.007
6	Grout Pressure	-1.067	0.017	-0.394	-0.176	0.109	0.012
		1.067	-0.017	0.394	0.176	0.547	0.017
7	Grout Pressure	-0.800	-0.352	-0.691	-0.459	0.509	-0.139
		0.800	0.352	0.691	0.459	0.527	-0.389
8	Grout Pressure	-0.777	-0.208	0.578	0.040	-0.756	-0.101
		0.777	0.208	-0.578	-0.040	-0.495	-0.351
9	Grout Pressure	-0.794	0.289	0.018	-0.041	0.508	0.044
		0.794	-0.289	-0.018	0.041	-0.520	0.148
10	Grout Pressure	-0.423	-0.132	0.040	0.005	-0.147	-0.072
		0.423	0.132	-0.040	-0.005	-0.026	-0.501
11	Grout Pressure	-1.047	-0.142	-0.011	0.002	0.043	-0.032
		1.047	0.142	0.011	-0.002	0.003	-0.585
12	Grout Pressure	-1.041	-0.143	0.009	0.000	-0.039	-0.033
		1.041	0.143	-0.009	-0.000	0.000	-0.588
13	Grout Pressure	-0.449	-0.137	-0.039	-0.009	0.144	-0.080
		0.449	0.137	0.039	0.009	0.027	-0.514
14	Grout Pressure	-0.792	-0.112	0.018	-0.041	0.496	-0.030
		0.792	0.112	-0.018	0.041	-0.508	-0.044
15	Grout Pressure	-0.759	0.092	-0.650	0.023	0.571	0.083
		0.759	-0.092	0.650	-0.023	0.838	0.117
16	Grout Pressure	-0.787	0.083	0.739	0.402	-0.594	0.086
		0.787	-0.083	-0.739	-0.402	-0.514	0.039
17	Grout Pressure	-1.369	0.863	-0.271	-0.085	0.511	1.090
		1.369	-0.863	0.271	0.085	-0.059	0.349
18	Grout Pressure	-1.409	0.561	-0.694	-0.013	0.206	-0.343
		1.409	-0.561	0.694	0.013	0.142	0.624
19	Grout Pressure	-1.689	0.001	0.258	-0.000	-0.201	0.000
		1.689	-0.001	-0.258	0.000	-0.100	0.000
20	Grout Pressure	-1.676	-0.005	0.000	0.000	0.067	-0.002
		1.676	0.005	-0.000	-0.000	-0.067	-0.002
21	Grout Pressure	-1.682	0.007	0.000	0.000	0.067	0.002
		1.682	-0.007	-0.000	-0.000	-0.067	0.004
22	Grout Pressure	-1.693	-0.000	-0.252	0.000	0.098	-0.000
		1.693	0.000	0.252	-0.000	0.196	-0.000
23	Grout Pressure	-1.434	-0.927	0.698	0.009	-0.138	-0.561
		1.434	0.927	-0.698	-0.009	-0.211	0.097
24	Grout Pressure	-1.395	-0.327	0.250	0.089	0.068	-0.106
		1.395	0.327	-0.250	-0.089	-0.484	-0.438
25	Grout Pressure	-0.636	-0.360	0.384	0.055	-0.197	-0.143
		0.636	-0.202	0.179	-0.055	0.021	0.063
26	Grout Pressure	0.248	-0.006	0.934	0.009	-0.636	-0.017
		-0.248	0.006	0.473	-0.009	0.300	-0.009
27	Grout Pressure	-0.017	-0.004	0.950	0.003	-0.641	-0.007
		0.017	0.004	0.456	-0.003	0.236	-0.008
28	Grout Pressure	0.001	-0.005	0.951	-0.004	-0.641	-0.010
		-0.001	0.005	0.456	0.004	0.235	-0.010
29	Grout Pressure	-0.003	-0.005	0.935	-0.010	-0.637	-0.010
		0.003	0.005	0.471	0.010	0.297	-0.010
30	Grout Pressure	-0.323	-0.026	0.383	-0.052	-0.176	-0.057
		0.323	0.026	0.179	0.052	-0.000	-0.052
31	Grout Pressure	0.424	-0.709	-0.006	0.011	0.009	-0.418
		-0.424	-0.416	0.006	-0.011	0.016	0.307
32	Grout Pressure	0.344	0.010	-0.022	-0.081	0.016	0.017
		-0.344	-0.010	0.022	0.081	0.074	0.023
33	Grout Pressure	-0.025	-0.721	-0.005	0.018	0.010	-0.443

		0.025	-0.404	0.005	-0.018	0.010	0.281
34	Grout Pressure	0.346	-0.630	0.000	0.083	0.001	-0.688
		-0.346	0.068	-0.000	-0.083	-0.003	-0.505
35	Grout Pressure	-0.332	-0.279	-0.014	0.059	0.013	-0.624
		0.332	0.279	0.014	-0.059	0.046	-0.529
36	Grout Pressure	0.000	0.002	0.007	-0.010	-0.031	0.004
		-0.000	-0.002	-0.007	0.010	0.001	0.003
37	Grout Pressure	-0.000	-0.002	0.008	0.008	-0.033	-0.004
		0.000	0.002	-0.008	-0.008	-0.001	-0.003
38	Grout Pressure	-0.448	0.258	-0.012	-0.058	0.009	0.561
		0.448	-0.258	0.012	0.058	0.042	0.505
39	Grout Pressure	0.421	0.229	0.007	-0.087	-0.006	0.462
		-0.421	-0.229	-0.007	0.087	-0.021	0.481
40	Grout Pressure	-0.675	-0.222	0.171	-0.538	-0.371	-0.336
		0.675	0.222	-0.171	0.538	0.085	-0.035
41	Grout Pressure	-0.669	0.026	-0.301	-0.238	-0.076	0.044
		0.669	-0.026	0.301	0.238	0.133	-0.039
42	Grout Pressure	-0.669	0.026	0.051	-0.238	-0.133	0.039
		0.669	-0.026	-0.051	0.238	0.057	-0.001
43	Grout Pressure	-0.665	0.009	-0.405	-0.001	-0.054	0.009
		0.665	-0.009	0.405	0.001	0.265	-0.005
44	Grout Pressure	-0.665	0.009	-0.003	-0.001	-0.265	0.005
		0.665	-0.009	0.003	0.001	0.267	0.001
45	Grout Pressure	-0.665	0.009	0.407	-0.001	-0.267	-0.001
		0.665	-0.009	-0.407	0.001	0.056	0.006
46	Grout Pressure	-0.660	0.010	-0.049	0.234	-0.059	0.004
		0.660	-0.010	0.049	-0.234	0.132	0.010
47	Grout Pressure	-0.660	0.010	0.334	0.234	-0.132	-0.010
		0.660	-0.010	-0.334	-0.234	0.069	0.011
48	Grout Pressure	-0.656	0.006	-0.137	0.531	-0.079	-0.002
		0.656	-0.006	0.137	-0.531	0.307	0.012
49	Grout Pressure	-0.350	0.413	-0.473	0.273	0.285	0.061
		0.350	-0.413	0.473	-0.273	0.425	0.559
50	Grout Pressure	-0.316	0.316	0.371	0.039	-0.445	0.154
		0.316	-0.316	-0.371	-0.039	-0.360	0.531
51	Grout Pressure	-0.356	-0.010	-0.057	-0.034	0.349	0.032
		0.356	0.010	0.057	0.034	-0.273	-0.045
52	Grout Pressure	-0.352	0.000	0.000	-0.000	0.000	0.000
		0.352	0.000	0.000	0.000	0.000	0.000
53	Grout Pressure	-0.402	0.000	0.000	-0.000	0.000	0.000
		0.402	0.000	0.000	0.000	0.000	0.000
54	Grout Pressure	-0.410	0.000	0.000	-0.000	0.000	0.000
		0.410	0.000	0.000	0.000	0.000	0.000
55	Grout Pressure	-0.383	0.000	0.000	0.000	0.000	0.000
		0.383	0.000	0.000	-0.000	0.000	0.000
56	Grout Pressure	-0.338	-0.027	-0.229	0.016	0.133	0.022
		0.338	0.027	0.229	-0.016	0.363	-0.081
57	Grout Pressure	-0.361	0.014	0.347	-0.315	-0.190	0.043
		0.361	-0.014	-0.347	0.315	-0.331	-0.022
58	Grout Pressure	-0.279	0.332	-0.102	-0.046	0.273	0.190
		0.279	-0.332	0.102	0.046	-0.083	0.425
59	Grout Pressure	-0.279	0.332	-0.455	-0.046	0.083	-0.425
		0.279	-0.332	0.455	0.046	0.059	0.529
60	Grout Pressure	-0.002	0.000	0.405	0.001	-0.010	-0.003
		0.002	-0.000	-0.405	-0.001	-0.202	0.003
61	Grout Pressure	-0.002	0.000	0.003	0.001	0.202	-0.003
		0.002	-0.000	-0.003	-0.001	-0.204	0.003
62	Grout Pressure	-0.002	0.000	-0.406	0.001	0.204	-0.003
		0.002	-0.000	0.406	-0.001	0.008	0.003
63	Grout Pressure	-0.258	-0.448	0.457	0.042	-0.058	-0.505
		0.258	0.448	-0.457	-0.042	-0.084	0.365
64	Grout Pressure	-0.258	-0.448	0.073	0.042	0.084	-0.365

	0.258	0.448	-0.073	-0.042	-0.220	-0.465

Steel Design Report

Checking GroutBoxFrame to ASD code
Tue, Jul 31, 2001 3:06 PM

Checking member 17

Group: Sq. Tube
Section: TS3.5x3.5x3/16

Load Case Grout Pressure

Fy=46 ksi
On gross area Ft=0.6*Fy=0.6*46=27.6 ksi
On net area Ft=0.5*Fu=0.5*58=29 ksi
Fv=0.4*Fy=0.4*46=18.4 ksi
Kl/r=max(Kx*l/rx,Ky*l/ry)=max(1*20/1.34,1*20/1.34)=14.925
Fa=(1-(KL/r)^2/(2*Cc^2)*Fy/FS=(1-14.925^2/(2*111.556^2)*46/1.717=26.558 ksi

Major Axis:
Fb=0.66*Fy=0.66*46=30.36 ksi
Minor Axis:
Fb=0.66*Fy=0.66*46=30.36 ksi

Member 17, Grout Pressure, Major bending
Tensile Bending Stress:
fb ≤ Fb, 5.339 ≤ 30.36 OK 82% under
Compressive Bending Stress:
fb ≤ Fb, 5.339 ≤ 30.36 OK 82% under

Member 17, Grout Pressure, Major shear
fv ≤ Fv, 0.658 ≤ 18.4 OK 96% under

Member 17, Grout Pressure, Minor bending
Tensile Bending Stress:
fb ≤ Fb, 2.503 ≤ 30.36 OK 92% under
Compressive Bending Stress:
fb ≤ Fb, 2.503 ≤ 30.36 OK 92% under

Member 17, Grout Pressure, Minor shear
fv ≤ Fv, 0.207 ≤ 18.4 OK 99% under

Member 17, Grout Pressure, Tension
On gross area ft ≤ Ft, 0.573 ≤ 27.6 OK 98% under
On net area ft ≤ Ft, 0.573 ≤ 29 OK 98% under

Member 17, Grout Pressure, Slenderness
Kx*Lx/rx=1*20/1.34=14.925 ≤ 300 OK 95% under
Ky*Ly/ry=1*20/1.34=14.925 ≤ 300 OK 95% under

Member 17, Grout Pressure, Bending & tension
fa/Ft+fbx/Fbx+fby/Fby=0.573/27.6+5.339/30.36+2.503/30.36=0.279 ≤ 1 OK 72% under

Member 17, Grout Pressure, Bending & compression
fa/Fa=0/26.558=0 ≤ 0.15 ∴
fa/Fa+fbx/Fbx+fby/Fby=0/26.558+5.339/30.36+2.503/30.36=0.258 ≤ 1 OK 74% under

Checking member 26

Group: Sq. Tube
Section: TS2x2x3/16

Load Case Grout Pressure

Fy=46 ksi
On gross area Ft=0.6*Fy=0.6*46=27.6 ksi
On net area Ft=0.5*Fu=0.5*58=29 ksi
Fv=0.4*Fy=0.4*46=18.4 ksi
Kl/r=max(Kx*l/rx,Ky*l/ry)=max(1*49.5/0.726,1*49.5/0.726)=68.182
Fa=(1-(KL/r)^2/(2*Cc^2)*Fy/FS=(1-68.182^2/(2*111.556^2)*46/1.867=20.033 ksi

Major Axis:
Fb=0.66*Fy=0.66*46=30.36 ksi
Minor Axis:
Fb=0.66*Fy=0.66*46=30.36 ksi

Member 26, Grout Pressure, Major bending
Tensile Bending Stress:
fb ≤ Fb, 0.312 ≤ 30.36 OK 99% under
Compressive Bending Stress:
fb ≤ Fb, 0.312 ≤ 30.36 OK 99% under

Member 26, Grout Pressure, Major shear
fv ≤ Fv, 0.008 ≤ 18.4 OK 100% under

Member 26, Grout Pressure, Minor bending
Tensile Bending Stress:
fb ≤ Fb, 11.422 ≤ 30.36 OK 62% under
Compressive Bending Stress:
fb ≤ Fb, 11.422 ≤ 30.36 OK 62% under

Member 26, Grout Pressure, Minor shear
fv ≤ Fv, 1.245 ≤ 18.4 OK 93% under

Member 26, Grout Pressure, Tension
On gross area ft ≤ Ft, 0 ≤ 27.6 OK 100% under
On net area ft ≤ Ft, 0 ≤ 29 OK 100% under

Member 26, Grout Pressure, Slenderness
Kx*Lx/rx=1*49.5/0.726=68.182 ≤ 200 OK 66% under
Ky*Ly/ry=1*49.5/0.726=68.182 ≤ 200 OK 66% under

Member 26, Grout Pressure, Bending & tension
fa/Ft+fbx/Fbx+fby/Fby=0/29+0.312/30.36+11.422/30.36=0.387 ≤ 1 OK 61% under

Member 26, Grout Pressure, Bending & compression
fa/Fa=0.195/20.033=0.01 ≤ 0.15 ∴
fa/Fa+fbx/Fbx+fby/Fby=0.195/20.033+0.312/30.36+11.422/30.36=0.396 ≤ 1 OK 60% under

<u>Checking member 34</u>


Group: Sq. Tube
Section: TS3.5x3.5x3/16

Load Case Grout Pressure
Fy=46 ksi
On gross area Ft=0.6*Fy=0.6*46=27.6 ksi
On net area Ft=0.5*Fu=0.5*58=29 ksi
Fv=0.4*Fy=0.4*46=18.4 ksi
Kl/r=max(Kx*l/rx,Ky*l/ry)=max(1*49.5/1.34,1*49.5/1.34)=36.94
$Fa=(1-(KL/r)^2/(2*Cc^2)*Fy/FS=(1-36.94^2/(2*111.556^2)*46/1.786=24.34$ ksi
Major Axis:
Fb=0.66*Fy=0.66*46=30.36 ksi
Minor Axis:
Fb=0.66*Fy=0.66*46=30.36 ksi

Member 34, Grout Pressure, Major bending
Tensile Bending Stress:
fb ≤ Fb, 3.369 ≤ 30.36 OK 89% under
Compressive Bending Stress:
fb ≤ Fb, 3.369 ≤ 30.36 OK 89% under

Member 34, Grout Pressure, Major shear
fv ≤ Fv, 0.48 ≤ 18.4 OK 97% under

Member 34, Grout Pressure, Minor bending
Tensile Bending Stress:
fb ≤ Fb, 0.014 ≤ 30.36 OK 100% under
Compressive Bending Stress:
fb ≤ Fb, 0.014 ≤ 30.36 OK 100% under

Member 34, Grout Pressure, Minor shear

fv ≤ Fv, 0 ≤ 18.4 OK 100% under

Member 34, Grout Pressure, Tension

On gross area ft ≤ Ft, 0 ≤ 27.6 OK 100% under

On net area ft ≤ Ft, 0 ≤ 29 OK 100% under

Member 34, Grout Pressure, Slenderness

Kx*Lx/rx=1*49.5/1.34=36.94 ≤ 200 OK 82% under

Ky*Ly/ry=1*49.5/1.34=36.94 ≤ 200 OK 82% under

Member 34, Grout Pressure, Bending & tension

fa/Ft+fbx/Fbx+fby/Fby=0/29+3.369/30.36+0.014/30.36=0.111 ≤ 1 OK 89% under

Member 34, Grout Pressure, Bending & compression

fa/Fa=0.145/24.34=0.006 ≤ 0.15 ∴

fa/Fa+fbx/Fbx+fby/Fby=0.145/24.34+3.369/30.36+0.014/30.36=0.117 ≤ 1 OK 88% under

End of check of GroutBoxFrame to ASD code

Steel Design Report

Checking GroutBoxFrame to ASD code

Tue, Jul 31, 2001 3:08 PM

Checking member 54

Group: Angle
Section: L2x2x3/16

Load Case Grout Pressure

Fy=36 ksi

On gross area Ft=0.6*Fy=0.6*36=21.6 ksi

On net area Ft=0.5*Fu=0.5*58=29 ksi

Fv=0.4*Fy=0.4*36=14.4 ksi

Kz*Lz/rz = 1*52/0.394 = 131.98

$Fa=12*\Pi^2*E/(23*(KL/r)^2)=12*\Pi^2*29000.996/(23*131.98^2)=8.573$ ksi

Major Axis:

Fb=0.6*Fy=0.6*36=21.6 ksi

Minor Axis:

Fb=0.6*Fy=0.6*36=21.6 ksi

Member 54, Grout Pressure, Major bending

Tensile Bending Stress:

fb ≤ Fb, 0 ≤ 21.6 OK 100% under

Compressive Bending Stress:

fb ≤ Fb, 0 ≤ 21.6 OK 100% under

Member 54, Grout Pressure, Major shear

fv ≤ Fv, 0 ≤ 14.4 OK 100% under

Member 54, Grout Pressure, Minor bending

Tensile Bending Stress:

fb ≤ Fb, 0 ≤ 21.6 OK 100% under

Compressive Bending Stress:

fb ≤ Fb, 0 ≤ 21.6 OK 100% under

Member 54, Grout Pressure, Minor shear

fv ≤ Fv, 0 ≤ 14.4 OK 100% under

Member 54, Grout Pressure, Tension

On gross area ft ≤ Ft, 0.573 ≤ 21.6 OK 97% under

On net area ft ≤ Ft, 0.725 ≤ 29 OK 98% under

Member 54, Grout Pressure, Slenderness

Kz*Lz/rz = 1*52/0.394 = 131.98 ≤ 300 OK 56% under

Member 54, Grout Pressure, Bending & tension

fa/Ft+fbx/Fbx+fby/Fby=0.573/21.6+0/21.6+0/21.6=0.027 ≤ 1 OK 97% under

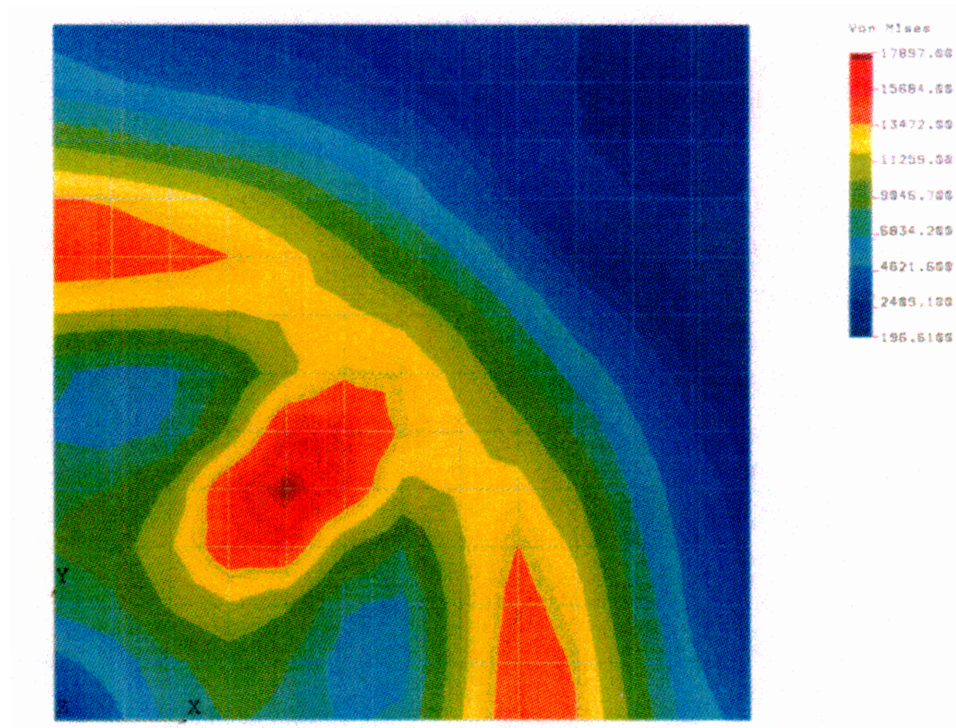
Member 54, Grout Pressure, Bending & compression

fa/Fa=0/8.573=0 ≤ 0.15 ∴

fa/Fa+fbx/Fbx+fby/Fby=0/8.573+0/21.6+0/21.6=0 ≤ 1 OK 100% under

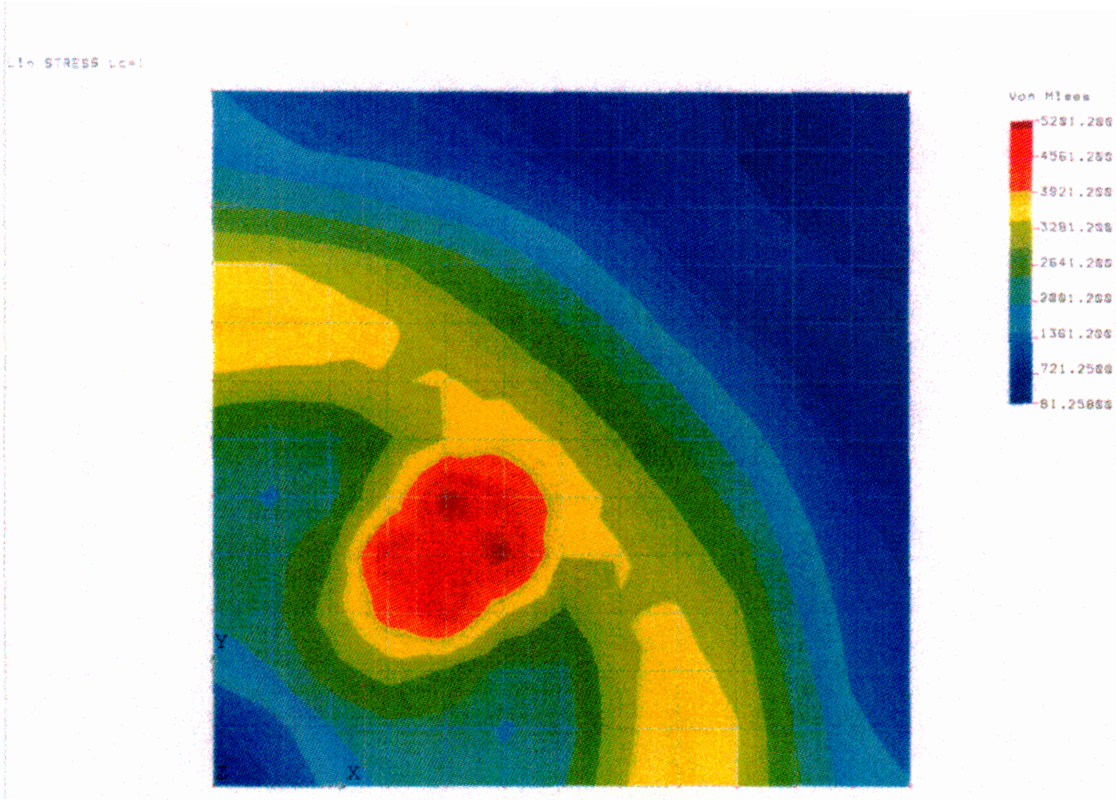
End of check of GroutBoxFrame to ASD code

GeoStar 2.6 (256K Version): Lug1 - [Main]



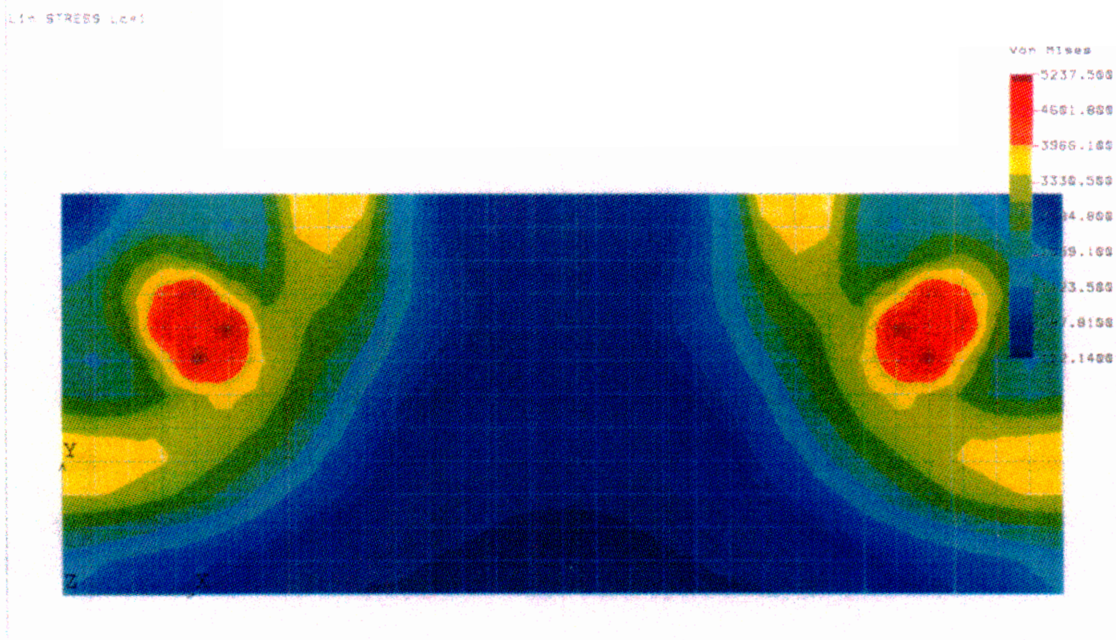
0.25" thick

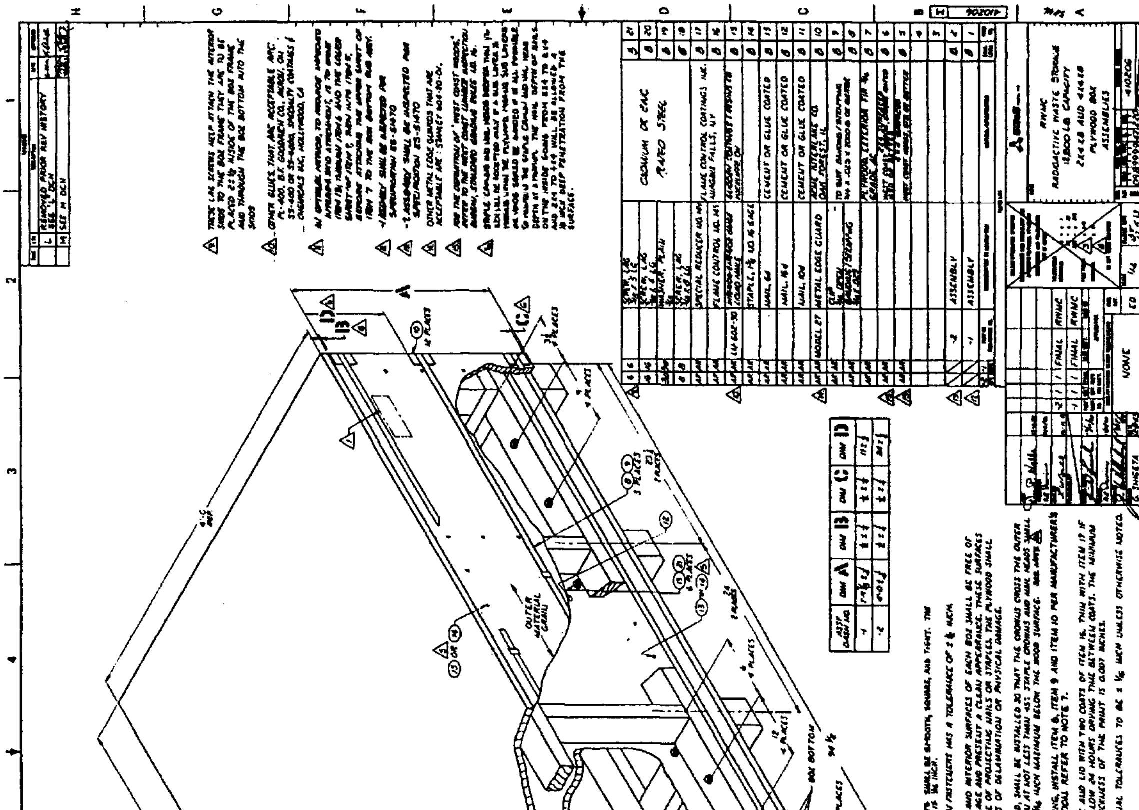
GeoStar 2.6 (256K Version): Lug1 - [Main]

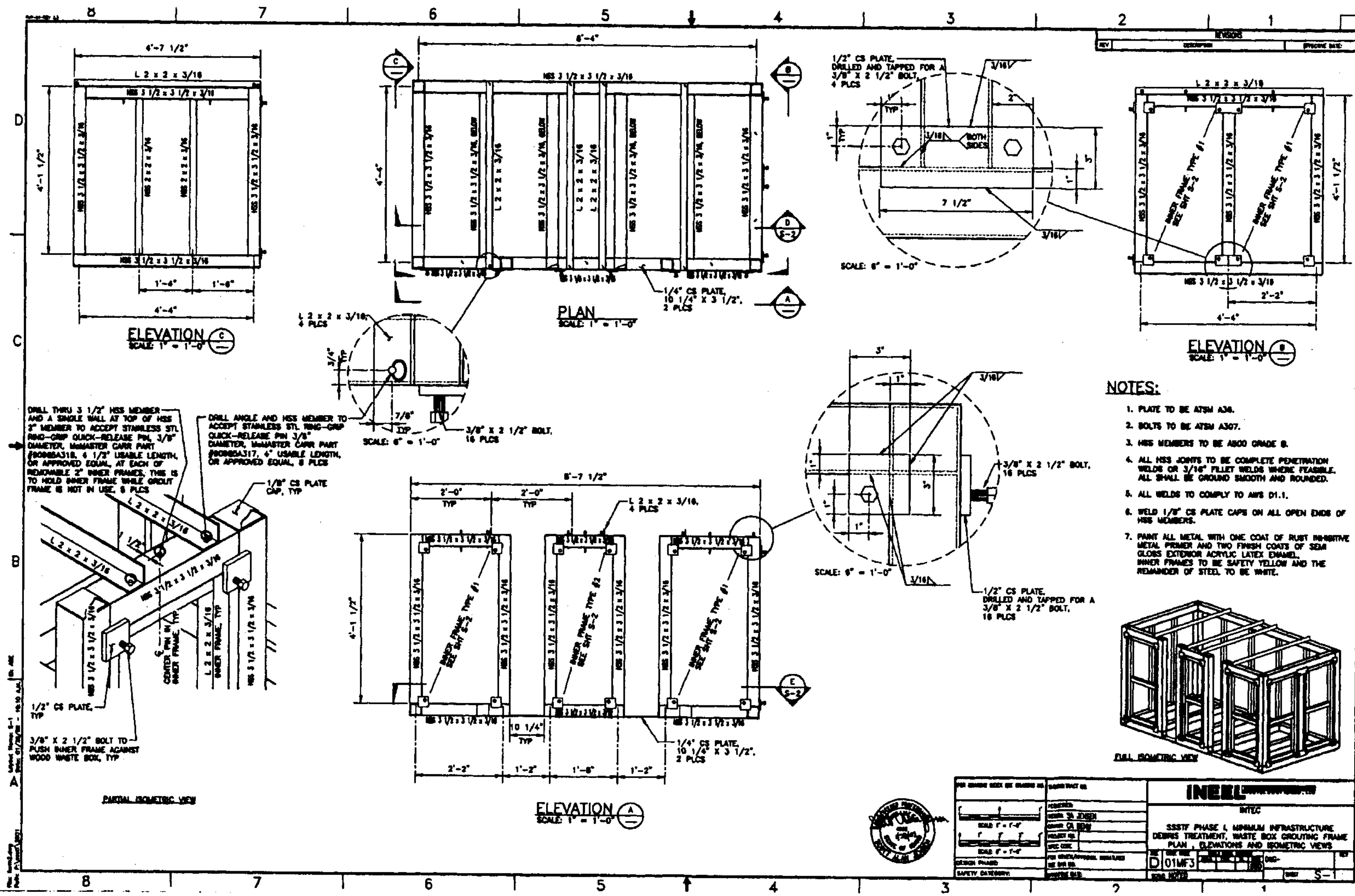


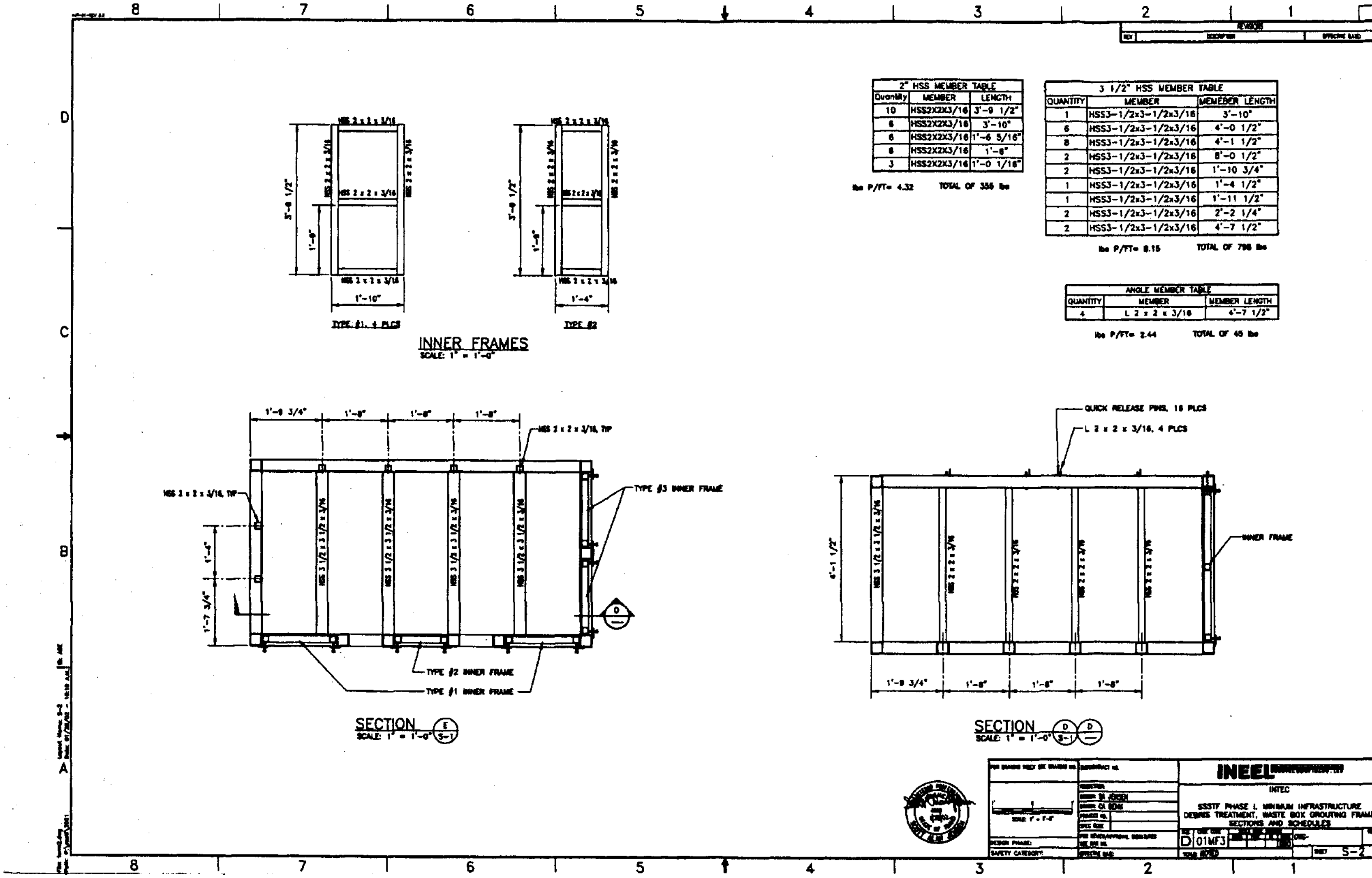
0.5" thick

GeoStar 2.6 (256K Version): Lug3 - [Main]






ELEVATION C
SCALE: 1" = 1'-0"
PLAN
SCALE: 1" = 1'-0"
ELEVATION B
SCALE: 1" = 1'-0"
ELEVATION A
SCALE: 1" = 1'-0"
SCALE: 6" = 1'-0"
HSS 3 1/2 x 3 1/2 x 3/16
L 2 x 2 x 3/16
HSS 2 x 2 x 3/16
INNER FRAME TYPE #1 SEE SHT S-2
INNER FRAME TYPE #2 SEE SHT S-2
1/4" CS PLATE, 10 1/4" X 3 1/2", 2 PLCS
L 2 x 2 x 3/16, 4 PLCS
3/8" X 2 1/2" BOLT, 16 PLCS
1/2" CS PLATE, DRILLED AND TAPPED FOR A 3/8" X 2 1/2" BOLT, 4 PLCS
1/2" CS PLATE, DRILLED AND TAPPED FOR A 3/8" X 2 1/2" BOLT, 16 PLCS
DRILL THRU 3 1/2" HSS MEMBER AND A SINGLE WALL AT TOP OF HSS 2" MEMBER TO ACCEPT STAINLESS STL RING-GRIP QUICK-RELEASE PIN, 3/8" DIAMETER, McMASTER CARR PART #90985A318, 4 1/2" USABLE LENGTH, OR APPROVED EQUAL, AT EACH OF REMOVABLE 2" INNER FRAMES. THIS IS TO HOLD INNER FRAME WHILE GROUT FRAME IS NOT IN USE, 8 PLCS
DRILL ANGLE AND HSS MEMBER TO ACCEPT STAINLESS STL RING-GRIP QUICK-RELEASE PIN 3/8" DIAMETER, McMASTER CARR PART #90985A317, 4" USABLE LENGTH, OR APPROVED EQUAL, 8 PLCS
1/8" CS PLATE CAP, TYP
1/2" CS PLATE, TYP
3/8" X 2 1/2" BOLT TO PUSH INNER FRAME AGAINST WOOD WASTE BOX, TYP
CENTER PIN IN INNER FRAME, TYP
PARTIAL ISOMETRIC VIEW
FULL ISOMETRIC VIEW
NOTES:
1. PLATE TO BE ATSM A36.
2. BOLTS TO BE ATSM A307.
3. HSS MEMBERS TO BE A500 GRADE B.
4. ALL HSS JOINTS TO BE COMPLETE PENETRATION WELDS OR 3/16" FILLET WELDS WHERE FEASIBLE. ALL SHALL BE GROUND SMOOTH AND ROUNDED.
5. ALL WELDS TO COMPLY TO AWS D1.1.
6. WELD 1/8" CS PLATE CAPS ON ALL OPEN ENDS OF HSS MEMBERS.
7. PAINT ALL METAL WITH ONE COAT OF RUST INHIBITIVE METAL PRIMER AND TWO FINISH COATS OF SEMI GLOSS EXTERIOR ACRYLIC LATEX ENAMEL. INNER FRAMES TO BE SAFETY YELLOW AND THE REMAINDER OF STEEL TO BE WHITE.
INEEL
INTEC
SSSTF PHASE I, MINIMUM INFRASTRUCTURE DEBRIS TREATMENT, WASTE BOX GROUTING FRAME PLAN, ELEVATIONS AND ISOMETRIC VIEWS
D 01MF3
S-1
SA JENSEN
REVISIONS
DESIGN PHASE:
SAFETY CATEGORY:



2" HSS MEMBER TABLE		
Quantity	MEMBER	LENGTH
10	HSS2X2X3/16	3'-9 1/2"
6	HSS2X2X3/16	3'-10"
6	HSS2X2X3/16	1'-6 5/16"
6	HSS2X2X3/16	1'-6"
3	HSS2X2X3/16	1'-0 1/16"

lbs P/FT= 4.32 TOTAL OF 356 lbs

3 1/2" HSS MEMBER TABLE		
QUANTITY	MEMBER	MEMEBER LENGTH
1	HSS3-1/2x3-1/2x3/16	3'-10"
6	HSS3-1/2x3-1/2x3/16	4'-0 1/2"
8	HSS3-1/2x3-1/2x3/16	4'-1 1/2"
2	HSS3-1/2x3-1/2x3/16	8'-0 1/2"
2	HSS3-1/2x3-1/2x3/16	1'-10 3/4"
1	HSS3-1/2x3-1/2x3/16	1'-4 1/2"
1	HSS3-1/2x3-1/2x3/16	1'-11 1/2"
2	HSS3-1/2x3-1/2x3/16	2'-2 1/4"
2	HSS3-1/2x3-1/2x3/16	4'-7 1/2"

lbs P/FT= 8.15 TOTAL OF 798 lbs

ANGLE MEMBER TABLE		
QUANTITY	MEMBER	MEMBER LENGTH
4	L 2 x 2 x 3/16	4'-7 1/2"

lbs P/FT= 2.44 TOTAL OF 45 lbs

Appendix C

Debris Box Bracing System Design Drawings

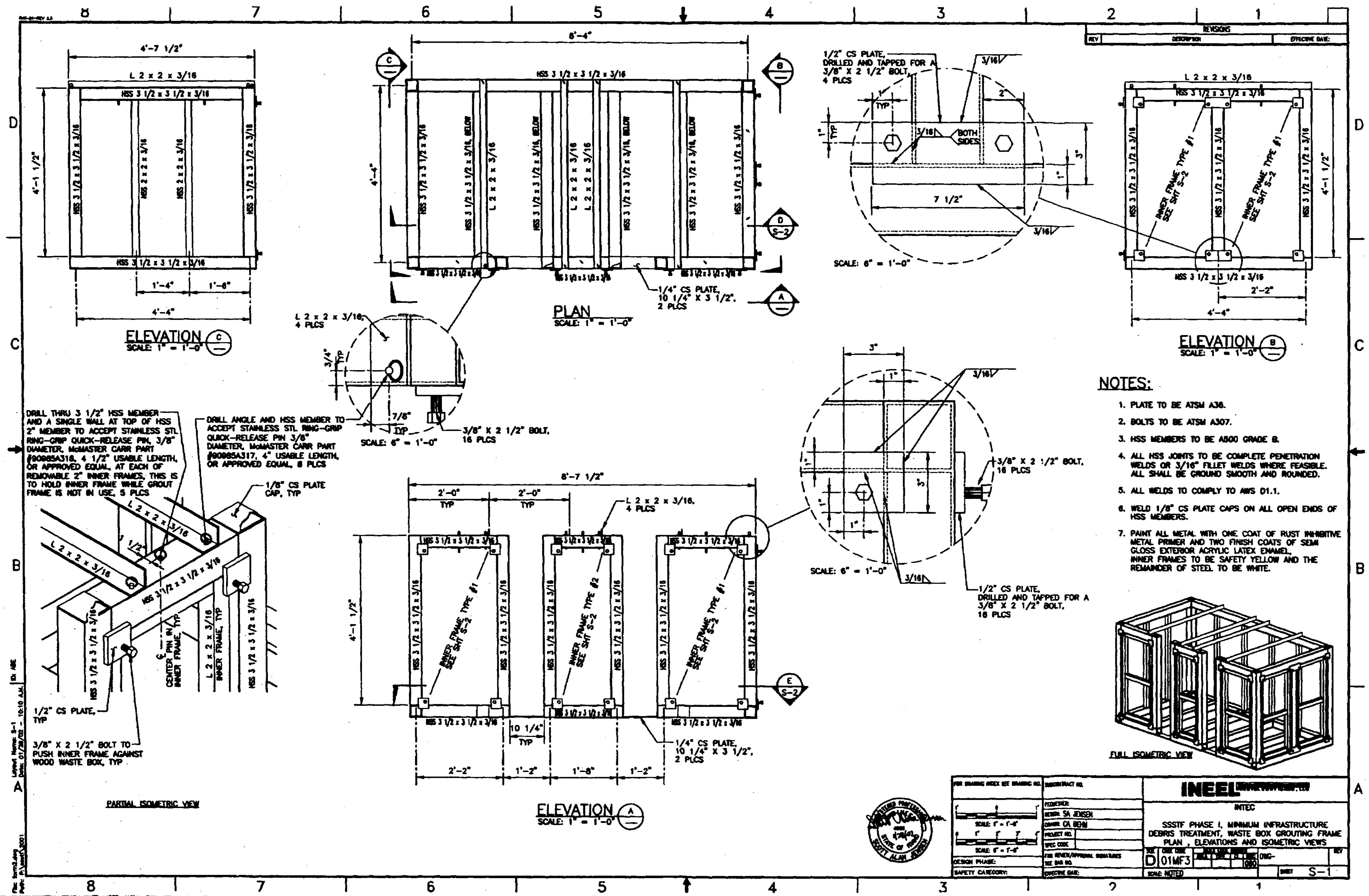


Figure C-1. SSSTF debris treatment waste box grouting frame, sections and schedule.

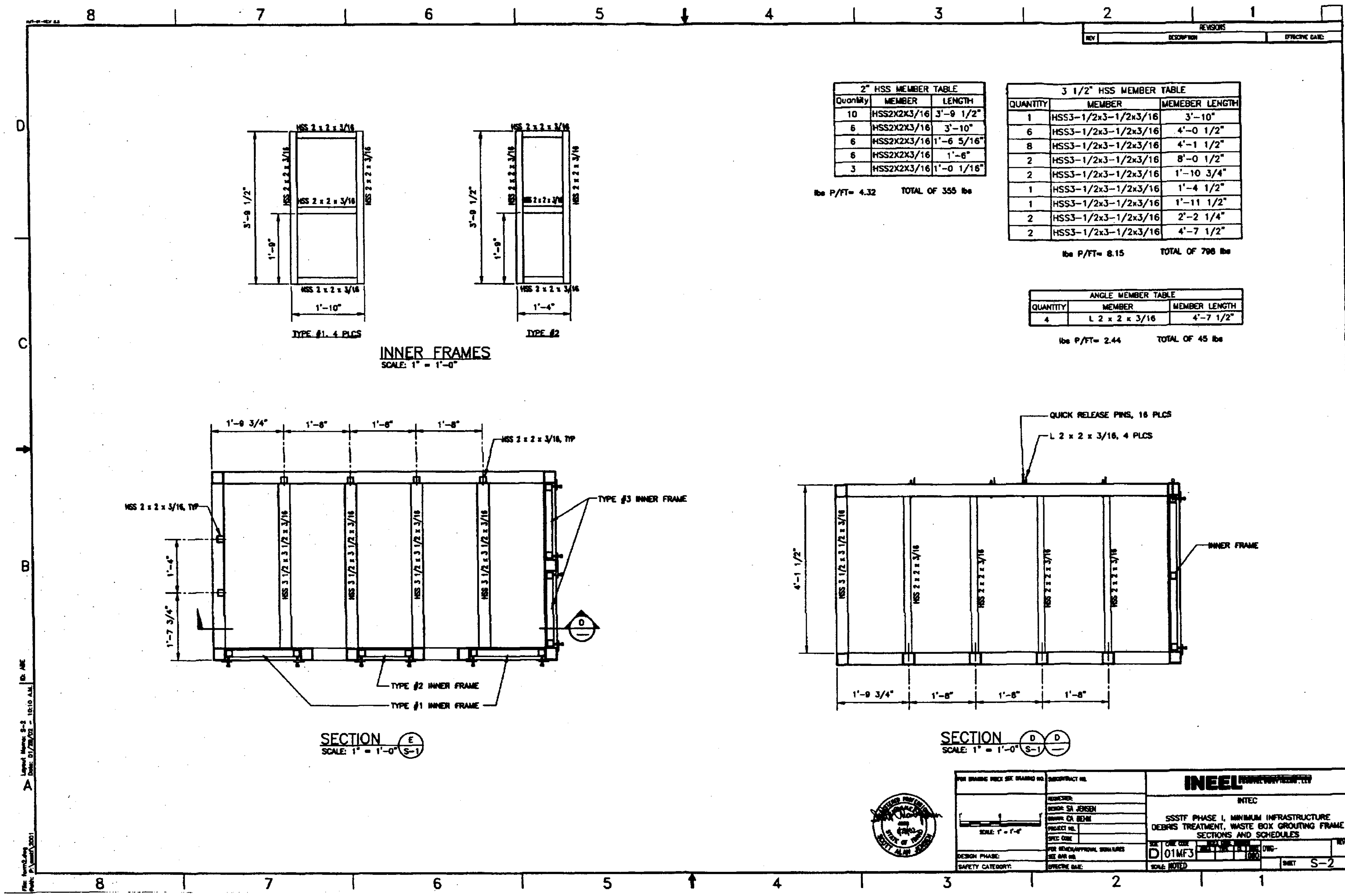


Figure C-2. SSSTF debris treatment waste box grouting frame plan, elevations and isometric views.